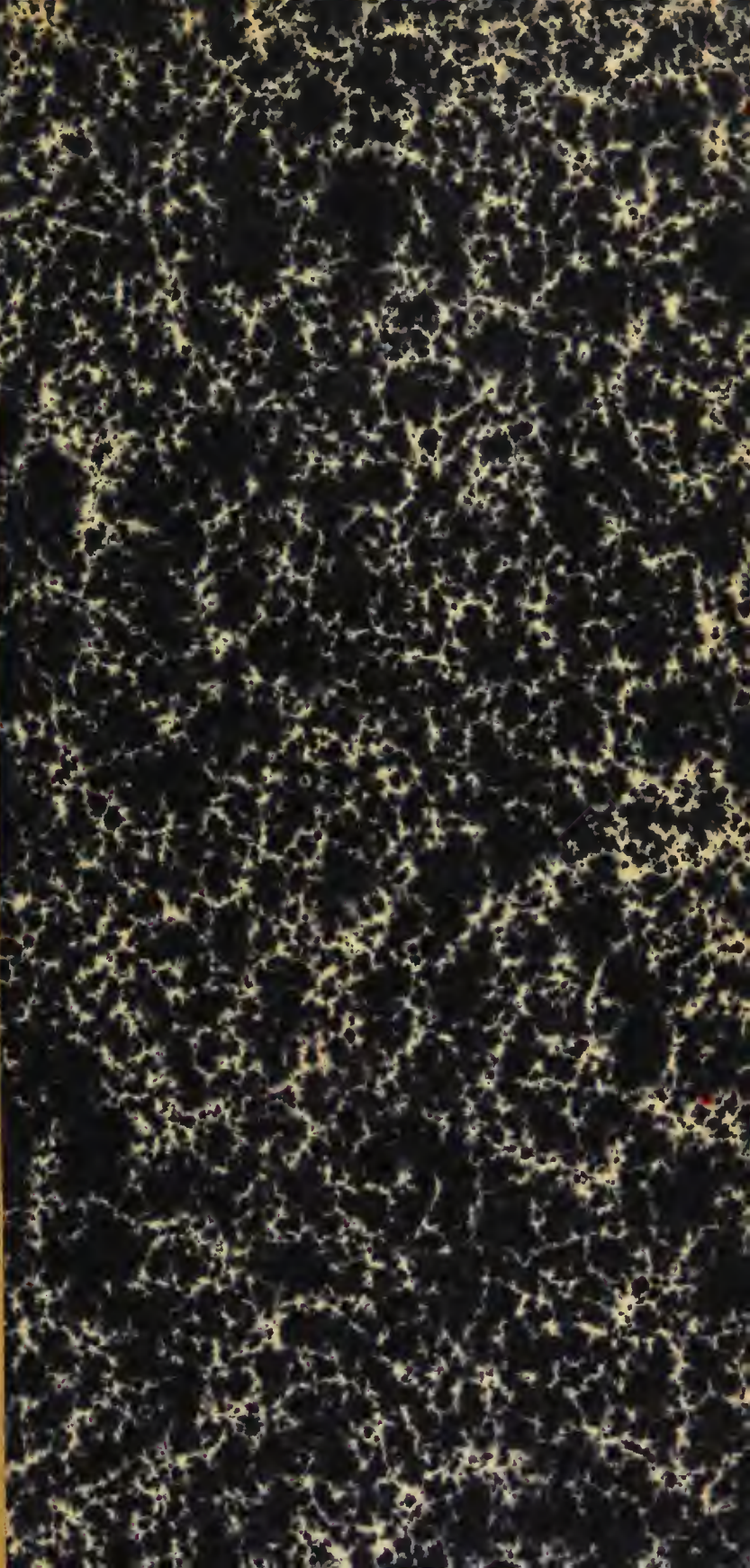

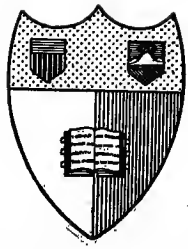

MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

EXPLANATION OF SHEET 316.

THE GEOLOGY

OF THE COUNTRY NEAR

FAREHAM

AND

HAVANT.

BY

H. J. OSBORNE WHITE, F.G.S.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HIS MAJESTY'S TREASURY.

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187. HUNTINGDON	—	6 0	—
203. BEDFORD	—	9 9	—
229. CARMARTHEN	1 6	1 6	2 0
230. AMMANFORD	1 6	1 6	2 6
231. MERTHYR TYDFIL ..	1 6	1 6	1 6
232. ABERGAVENNY ..	1 6	1 6	2 0
246. WEST GOWER	1 6	1 6	0 6
247. SWANSEA	1 6	1 6	2 6
248. PONTYPRIDD	1 6	1 6	1 6
249. NEWPORT (MON.) ..	1 6	1 6	1 6
254. HENLEY-ON-THAMES	—	1 6	2 0
261-2. BRIDGEND	1 6	1 6	1 6
263. CARDIFF	1 6	1 6	2 0
267. HUNGERFORD and NEWBURY	—	1 6	2 6
268. READING	6 9	1 6	1 6
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284. BASINGSTOKE	—	1 6	2 0
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298. SALISBURY	—	1 6	1 3
299. WINCHESTER	—	1 6	1 6
300. ALRESFORD	—	1 6	2 0
311. WELLINGTON and CHARD	—	1 6	1 3
314. RINGWOOD	—	1 6	1 0
315. SOUTHAMPTON ..	—	1 6	1 6
316. HAVANT	—	1 6	—
317. CHICHESTER	—	1 6	1 0
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326 and 340. SIDMOUTH and LYME REGIS ..	—	1 6	1 6
328. DORCHESTER ..	—	1 6	1 0
329. BOURNEMOUTH ..	6 3	1 6	0 4
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334. NEWHAVEN and EASTBOURNE ..	—	1 6	0 6
335. TREVOSE HEAD ..	—	1 6	2 3
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ENGLAND AND WALES.

EXPLANATION OF SHEET 316.

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OF THE COUNTRY NEAR

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PREFACE.

The area covered by Sheet 316 of the New Series one-inch map is included in the Old Series Sheets 11, 10, and 9, and was originally surveyed by H. W. Bristow. Sheet 10 was published in 1856 and Sheet 11 in 1858, with a new edition in 1868, while Sheet 9 followed in 1864, with a revision of the Chalk and Tertiary areas in 1893 by C. Reid.

The re-survey on the six-inch scale, from which the one-inch Sheet 316 has been reduced, was carried out by W. Whitaker, C. Reid, and C. E. Hawkins, and was published in the Drift Edition as a hand-coloured map in 1900. In 1905 the Sheet was issued in colour-printed form.

Except for some observations included by A. J. Jukes-Browne in the General Memoir on the Cretaceous Rocks of Britain (1900-1904), and some well-sections contained in the Water Supply of Hampshire (1910) and in the Water Supply of Sussex (1899 and 1911), no explanation of the geology of Sheet 316 had been published. It was fortunate, therefore, that Mr. Osborne White was able to undertake the preparation of this Sheet Memoir, and to add thereby one more to the list of valuable memoirs for which we are indebted to him. The volume is founded largely on original observations made by Mr. White himself, but he desires also to acknowledge assistance rendered by Messrs. R. M. Brydone, Ll. Treacher, W. D. Lang, T. H. Withers, and A. S. Kennard and Dr. A. W. Rowe.

J. J. H. TEALL,
Director.

Geological Survey Office,
28, Jermyn Street, London.
3rd November, 1913.

(29477—17.) Wt. 653—56. 500. 2/14. D & S.

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ILLUSTRATIONS.

THE GEOLOGY

OF THE COUNTRY NEAR

FAREHAM

AND

HAVANT.

CHAPTER I.

INTRODUCTION.

Area and Location.—The country represented on the Fareham Sheet (No. 316) of the one-inch Ordnance Survey Map has an area of between 216 and 217 square miles, of which about 170 are in the south-eastern part of Hampshire, and the remainder in south-western Sussex. Of the four small towns included, Fareham, Havant, and Emsworth lie in the south, and Bishop's Waltham in the north-west. These, and the villages of Titchfield, Wickham, Hambledon, East Meon, and Buriton, belong to the Hampshire division of the district, while the Hartings, Westbourne, and Bosham are among the Sussex villages that fall within its limits, towards the east.

The principal lines of communication are the highways from Portsmouth and from Gosport to London, the coast road connecting Southampton and Chichester, and the London and South Western and London, Brighton, and South Coast Railways.[1]

Physical Features.—The westernmost division of the South Downs, culminating in the dome-like mass of Butser (889 feet), extends through the northern part of the district, for a distance of about 10 miles, to the natural termination of the range at Old Winchester Hill.

From the deeply-indented crest-line east of Butser Hill there is a steep descent northward, of 400 or 500 feet, to the malmstone terrace which supports the villages of Buriton and Harting; and beyond this comes another quick descent, of 100 feet or so, to the low ground on the Gault and Lower Greensand near Petersfield, in the area of the Weald.

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[1] The current issue of the colour-printed edition of Sheet 316 (dated 1905) shows neither the Meon Valley Branch of the London and South Western Railway nor the Cosham and Horndean Light Railway. The former follows the Meon Valley down to a point about two miles south-west of Wickham, and bears thence south-eastward to Fareham. The latter follows the Portsmouth-Guildford (and London) road.

West of Butser, the converging ranges of the South Downs and the Alton Hills close in around the broad, compound combe or vale of East Meon, and unite in the neck of high ground at Old Winchester Hill, which separates that combe from the neighbouring vale of Warnford and Exton.

Southward from the crest of the Downs, the Chalk country—furrowed, as elsewhere, by numerous branching valleys—falls away at a moderate inclination to the wooded tract of the Forest of Bere, on the Eocene strata, 4 or 5 miles distant; the general decline being interrupted, however, in many places, by isolated hills and outstanding masses of downland, such as Windmill Hill (635 feet), between Chalton and Clanfield. Villages hereabouts occur almost as frequently on the ridges as in the bottoms.

In the belt of clayey and sandy country that extends through Havant Thicket, the Forest of Bere, and Waltham Chase, the relief is mostly slight, the greater part of the ground lying below the contour of 200 feet, and exceeding the 300 feet level nowhere save in the wooded hill above Rooksbury (315 feet), east of Wickham. Here the older villages, such as Southwick and Wickham, are few and widely spaced, but of late years residential settlements of considerable size have grown up about some of the hamlets, as at Waterloo (now Waterlooville), Shidfield, and Curdridge.

Southward again, there comes the long, grassy chalk-ridge of Portsdown, contrasting in form and hue with the undulating heath and woodland of the Forest, from which it rises with a graceful curve. The Down declines gently eastward and westward from a point above 400 feet near Southwick: on its quarry-scarred southern face the ground falls steeply at first, and then with a moderate inclination, that merges at length in the levels along the coast.

The view from the summit of Portsdown embraces the greater part of the area under consideration. North and north-eastward, it is true, the prospect is limited by the broken sky-line of the South Downs, but in other directions the field of observation is wide indeed; and the outlook over the coastal plain, with its broad island-dotted harbours, scattered farmsteads, and smoking towns, is among the most remarkable in the south of England.

The district is traversed by no important stream, unless the Wallington River be so regarded, on account of interests and sentiments associated with its estuary, Portsmouth Harbour. The whole of the local surface-drainage is carried to the English Channel; partly by the Rother-Arun, of which the Criddell and other small branches rise near Ramsdean, Buriton, and South Harting; but mainly by a number of independent streams that run directly to the coast, and include the Rivers Hamble, Meon (or Titchfield), Wallington, and Ems; and the Havant and Bedhampton brooks. All are fed by springs from the Chalk, and most of them have their origin in such springs. The Meon, indeed, receives little water from any other source; whereas the Hamble and the Wallington are supplied largely by surface-water from the clay grounds of Waltham Chase or the Forest of Bere.

Geological Formations.—The following formations, represented at the surface in this district, are distinguished in the colour-printed edition of Sheet 316:—

Recent	Alluvium	
Pleistocene	Brickearth.	
	River and Valley Gravel.	
	Raised Beach.	
Pleistocene and Pliocene?	Plateau Gravel.	
	Clay-with-Flints.	
Eocene	Bracklesham Beds.	
	Bagshot Sands.	
	London Clay.	
	Reading Beds.	
Upper Cretaceous ...	Upper Chalk.	
	Middle Chalk.	
	Lower Chalk.	
	Upper Greensand	Selbornian.
	Gault	
Lower Cretaceous ...	Folkestone Beds ...	Lower Greensand.
	Sandgate Beds ...	

No rocks older than the Sandgate Beds are known to have been reached in any local boring, but it is highly probable that the inferior members of the Lower Greensand, and the Weald Clay, which crop out near Rogate immediately to the north, and also in the Isle of Wight about 12 miles to the south, underlie the Upper Cretaceous throughout the district. It is little less probable that the Wealden Beds pass down into the Purbeck, which elsewhere in the south of England rests on Portlandian strata, and these in turn on older stages of the upper Jurassic Series. The descending succession may well resemble that seen on the Dorset coast; and, in any case, it is likely that the Cretaceous Beds are separated by a great thickness of older Secondary sediments from the sunken platform of Primary or Palaeozoic rocks below. The chances in favour of Coal Measures being met with at a workable depth are, therefore, discouragingly small.

The tectonic structure of the district—as far as the visible rocks are concerned—is discussed in Chapter XII.

Industries.—Besides agriculture, the local industries closely connected with geology are quarrying, lime-burning, and the manufacture of bricks, tiles, pottery, and whiting. Some remarks on these subjects, and on the water supply, will be found under the heading of Economic Geology, at the end of this memoir.

CHAPTER II.

LOWER GREENSAND.

Sandgate Beds.

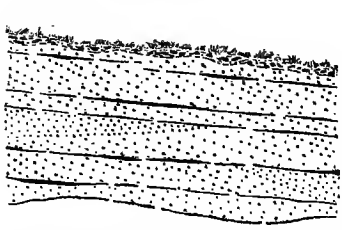
These are mapped as outcropping in a little triangular area by the brook east of Habin, near the north-eastern corner of the district. A short distance north of this (in the area of Sheet 300) the banks of the River Rother, and of the hollow lanes nearer Rogate, show interbedded brown loams and sands, with the characteristic small, polished pebbles of iron-ore.

The formation is estimated to be about 70 feet thick in this neighbourhood.

Folkestone Beds.

The highest division of the Lower Greensand here consists of yellow and white sands, with some thin seams of pale red-grey laminated clay near their upper limit. The sands vary in texture from bed to bed, but are mostly rather coarse and micaceous in the upper parts, and finer below. They are strongly current bedded, the prevailing inclination or dip of the laminae being towards the south. Near the middle of the formation, especially, parts of the sand are strongly ferruginous, and contain seams of iron-sandstone (carstone), which, however, are much less developed than in the country north of Petersfield.

Fig. 1.—*Stratification and Current-bedding in the Folkestone Beds, West Heath Common.*



In the area under consideration, neither the lowest nor the highest beds are exposed. In the adjoining area of the Chichester map (Sheet 317), to the east, a thin bed of crimson ironstone grit occurs at the junction with the Gault.

Locally, the Folkestone Beds seem to be about 150 feet thick. They are not known to be fossiliferous, but careful examination of the carstone concretions might reveal casts of wood and or marine lamellibranchs, such as are occasionally met with elsewhere in the Wealden area.

Notes of Exposures.

A well-boring at the "Jolly Sailors" inn, at the Causeway, proved 107 feet of light-coloured sands and soft sandstone below beds referred to the Gault.

Small exposures of yellow sand are to be seen to the west of Heath Pond.

At West Heath a pit on the eastern side of the road to West Harting shows about 30 feet of dark yellow, ironstained, micaceous sand, near the upper limit of the formation. The sand, which has a 'fore-set' structure, is divided into definite beds by partings of silty clay that indicate a dip of 3° to 4° south (Fig. 1).

A good section of beds at about the same horizon is presented in a pit at the southern end of the deep road-cutting by Sandhill House. About 50 feet of lower beds, consisting of light yellow to pure white sand (the former with concretionary ironstone), appear in the cutting itself, and in an adjacent pit in the western side of the road. Here the clay-seams are wanting, but the stratification is clearly marked by planes which are independent of the current-bedding. Under the microscope, the fine white sand exposed near the northern end of the road-cutting is seen to consist of clear quartz-grains, of sharply angular to sub-angular forms, with a small proportion of well-rounded grains of larger size than the rest.

CHAPTER III.

SELBORNIAN BEDS: GAULT AND UPPER GREENSAND.

As far as can be seen, the Selbornian has much the same facies as in the neighbourhood of the Hampshire village whence it derives its name. Here as there, the dark grey clays and marls forming its lower, or Gault, division are succeeded by the grey siliceous and calcareo-siliceous malmstone mapped as Upper Greensand; but at the top of the series there is a small thickness of glauconitic sand or sandstone which is wanting at Selborne, 6 or 7 miles to the north.

The Selbornian Beds are usually grouped under the following zonal headings, which are given in descending order:—

Zone of Pecten asper and Cardiaster fossarius.
„ Schloenbachia rostrata { Sub-zone of Schloenb. goodhalli, „ Schloenb. varicosus.
„ Hoplites lautus.
„ Hoplites interruptus.
„ Douvilleiceras mammillatum.

The succession so far made out in the western part of the Wealden area, between Farnham and Petersfield, is as follows:—

Chloritic Marl (base of the Chalk).

Upper Greensand (150 ft. ?)

? Zone of Pecten asper.
8. Green sand and sandstone.

Zone of Schloenbachia rostrata.
7. Soft, marly, micaceous, grey malmstone, with some glauconite, passing down into harder, blocky or massive grey malmstone—partly calcareous, partly purely siliceous,—alternating with thinner laminated beds of softer, silty malm, and containing regular courses and impersistent bands of grey-blue calcareous malmstone, and ill-defined masses of bluish chert.
6. Soft, non-calcareous, silty brown-grey malm in thin beds, becoming increasingly argillaceous towards the base.

Gault (200 ft. ?)

Zone of Schloenbachia rostrata.
5. Grey-brown silty clay, passing into
4. (*S. varicosus* Sub-zone) Stiff, dark grey-blue clay and marl, with selenite and phosphatic nodules.

Zone of Hoplites interruptus.
3. Clay and marl, like that above.
2. Stiff, dark blue-grey clay; partly calcareous, and containing phosphatic nodules, some selenite, and bands of impure limestone.

Zone of Douvilleiceras mammilatum.
1. Dull greenish-grey and brown sandy clay, with small quartz-pebbles and phosphatic nodules, passing down into pebbly loam and sand with similar nodules.

Sand (top of Lower Greensand).

In the present district, the lowest and highest beds of the Gault, and the inferior parts of the Upper Greensand, are either invisible or but poorly exposed. At Stroud Common, west of Petersfield and half a mile beyond the northern boundary of Sheet 316, the lowest part of the Gault is loamy sand, with a seam

of quartz-pebbles, but without the phosphatic nodules, such as have preserved relics of the Mammillatum-zone fauna near Farnham; while near Midhurst, to the east, the clay is separated from the Folkestone sand by a band of red grit, only a few inches thick.

It is probable that the bulk of the local Gault clays belong to the Zone of *Hoplites interruptus*, as in the vicinity of Selborne, and that the Zone of *Schloenbachia rostrata* includes their highest beds, together with the whole of the overlying malmstone. This last is a fine-grained rock, composed mainly of colloid silica in minute granules and spheriods, mixed with siliceous sponge-spicules and a small proportion of fine arenaceous and argillaceous sediment. Some of the malmstone beds—chiefly the higher—are markedly calcareous. These 'rag' beds can usually be distinguished from the purely siliceous beds by their greater density and hardiness: they frequently have a blue tint. Nodules of chert and small phosphatic concretions are common. Fossils seem generally scarce; the few noticed by the writer occurred in the upper beds.

Of the greensand which immediately underlies the Chalk, no satisfactory sections are at present to be seen. It merges into the malmstone below and the Chloritic Marl above; and its thickness at Barrow Hill, near East Meon, has been diversely estimated as about 4 feet and 16½ feet. It is composed mainly of glauconite grains in a fine siliceous ground-mass, similar to that of the malmstone. Fine quartz sand is present, and in the upper parts, at least, there is some admixture of marl. The greensand was not seen eastward of Barrow Hill within the present district, but it may be continuous with the similar deposit observed at Barlavington and Bury, south of Petworth. Professor C. Barrois has suggested its correlation with the Zone of *Pecten asper*.[1]

Notes of Exposures.

Gault.—The only good section in the *Hoplites interruptus* Zone is given in the brickyard south-west of Rogate railway station, and north-east of the disused brickyard marked on the map. The pits there show about 40 feet of marly clay; brown, silty, and containing impersistent bands of light-grey argillaceous limestone, in the upper part; dark-grey to black, tenacious, and containing much race and nodular phosphatic matter, in the lower part. In the dark clay fossils are plentiful, but badly decayed. Those identified were *Inoceramus concentricus* Park., *Lima* (*Mantellum*) *gaultina* Woods, and *Hoplites interruptus* (Brug.), the first and last of these being abundant.

Poor exposures of beds at about the same horizon were seen in the brickyards at the Causeway.

Dark-grey laminated silty clay, in the upper part of the Gault, is dug in shallow brick-pits in a meadow a quarter of a mile north of West Harting. Fossils occur in the form of phosphatic casts, but they are scarce, and the writer can record only

[1] "Recherches sur le terrain Crétacé supérieur de l'Angleterre, &c." *Mem. Soc. Géol. du Nord*, 1876, p. 36.

Granularia sp., *Inoceramus concentricus* Park. (small form), ? *Parahoplites vesicostatus* (Mich.), and a few indeterminable ammonoid fragments.

Malmstone.—This division of the Selbornian seems to be about 150 feet thick near Buriton and South Harting. The soft passage-beds into the Gault, outcropping along the foot of the malmstone escarpment, are generally overspread by wash from the higher ground and are seldom exposed. On the other hand, sections in the firm rock which constitutes the bulk of the Upper Greensand are to be seen in the banks of most of the roads which ascend the malmstone escarpment, as well as in many hollow ways and ravines to the south of that feature. There are noteworthy exposures of this sort on the road from South Harting to Rogate Station; at Nursted Rocks north-west of Nursted, and in the ravines to the south-east of that hamlet; on the road north of Bolingehill Farm, and on that east of Twentyways Farm.

Beds of bluish rag have been quarried by the road-side west of Nursted. They are interstratified with speckled grey stone, in which a foraminifer (*Rotalia sp.*) is common.

At the north-eastern end of Buriton a small pit shows 10 feet of light blue-grey, flaggy rock with phosphatic concretions, alternating with thinner bands of friable grey malm. Opaque white chert occurs in nodules and in veins filling joint-fissures. Small *Ostreae* and *Pecten* (*Syncyclonema*) *orbicularis* J. Sow., are common, and casts of the tubes of some boring animal are noticeable in the bluish stone.[1]

In the road-cutting a quarter of a mile east of Twentyways Farm, near Ramsdean, an 18-inch band of bluish-grey rag is shown, the weathered surface of which exhibits an irregular ridging, suggestive of a deformed lenticular structure within. West of the cutting, and at a rather higher level, a field-pit north of the road shows about 10 feet of grey and bluish blocky malmstone in well-marked beds. Near the top of the working is a layer of dark-grey siliceous stone, which undergoes spheroidal exfoliation on exposure. The beds in the middle and lower parts of the section are fossiliferous, the most common forms being—*Grammatodon carinatus* (J. Sow.), *Ostrea vesiculosa* J. Sow., *Pecten* (*Neithea*) *quinquecostatus* J. Sow., *P.* (*Syncyclonema*) *orbicularis* J. Sow., *Plicatula gurgitis* Pict. and Roux., and *Schloenbachia rostrata* (J. Sow.). In some cases the tests of lamellibranchs are silicified.

Light-grey calcareous malmstone, looking much like chalk, and containing a little bluish chert, is shown in the banks of the road through Ramsdean, and in a pit at the eastern end of the village.

Greensand.—The late William Topley, writing about the year 1875, states that "the whole thickness of the greensand may be

[1] R. I. Murchison (*Trans. Geol. Soc.*, vol. ii, 1829, p. 99) records the following Upper Greensand ('firestone') fossils, "chiefly from Nursted and Buriton"—"*Ammonites rostratus*, *Pecten orbicularis*, *Gryphaea vesiculosa*, *Avicula sp.*, *Echinospatagus*, Fish : 2 fin, of *Balistes*." W. H. Fitton (*ibid.* ser. 2, vol. iv, 1836, pp. 156, 157) gives a longer additional list, from the "vicinity of Petersfield," which includes "*Pecten asper*."

seen by the road-side to the north-west of Barrow Hill. The chalk marl in its lowest beds contains a few green grains, which increase in number below, the beds at the same time becoming sandy, and thus pass into greensand. This is whitish in its upper part, but becomes darker below. Still lower it passes as gradually into Malm Rock. The thickness from good Chalk Marl to good Malm Rock is 8 to 10 feet, of good greensand about 4 feet."[1]

Professor Barrois' account of this section differs from the above in several particulars. He writes, "to the north of Barrow Hill, at the point where four roads meet, the banks are in a coarse quartzose greensand alternating with harder layers of the grey sandstone [malmstone] of Langrish: *Pecten laminosus* [*P.* (*Syncyclonema*) *orbicularis*] is here abundant. Following the road which leads thence towards East Meon, the beds of sandstone [? malmstone] are seen to become less frequent, the greensand alone continuing, and being ultimately covered by a bed of marly limestone [Chloritic Marl] with numerous dark-green grains of glauconite and brown phosphatic nodules."[2]

This section has long since become obscured. In 1909 a little dark-green sand, yielding *P. orbicularis*, was exposed in the ruts of the cartway leading southward to Barrow Hill. Nearer East Meon the sand reappears, as a small inlier, in the hollow lane a quarter of a mile north of Lower House Farm. "The banks for some distance on the south side of the lane," writes Topley, "are formed of this bed, and a good opportunity is afforded of seeing its horizontal variations. Generally it is a soft and somewhat clayey greenish sand, but hardening sometimes into an irregularly bedded green sandstone, and elsewhere into a bed somewhat resembling Malm Rock, but still with green grains. Phosphatic nodules occur, but are not very plentiful. The thickness seen is from 6 to 8 feet." Some of this sand and sandstone is still to be seen in the channel of the brook that flows beside the lane. Samples examined by the present writer consisted of closely-compacted, rounded and rod-shaped grains of dark-green glauconite, in a paste of light-grey malm, or of malm and marl.

[1] 'Geology of the Weald,' *Mem. Geol. Surv*, 1876, p. 157

[2] 'Recherches sur le terrain Crétacé, &c,' 1876, p. 36.

CHAPTER IV.

CHALK.

Excluding the portions covered by the Eocene deposits, the Chalk occupies rather more than half of the country under consideration. Its thickness is not known exactly, but probably does not fall short of 1,200 feet in the southern part of this district, where the formation is most fully developed.

The three stages into which the Chalk is divided on the map are distinguished by certain broad lithological features, of which a synopsis is given below:—

Upper Chalk.—Typically a pure white chalk; mostly soft to firm and homogeneous, but becoming hard and nodular, and assuming a greyish tint, towards the base.
Flints are abundant almost throughout.

Middle Chalk.—White to greyish white; mainly soft to firm, but containing hard nodular beds in the lower part, and, to a less extent, in the higher part also.
Flints are scarce, save in the highest beds.

Lower Chalk.—Pale yellowish-white, firm chalk in the upper part; grey-blue to grey-brown marl and marlstone in the lower part; speckled green glauconitic ('Chloritic') marl at the base.
Flints are absent, or exceedingly rare.

In the absence of a well-marked hard bed, such as the Chalk Rock, at the base of the Upper Chalk, the junction of this stage with the Middle Chalk is difficult to follow in the field. The boundary of the Upper Chalk as shown on the map appears to have been drawn, as a rule, along the base of the markedly flint-bearing beds, that is to say, at a horizon rather below the top of the Middle Chalk.

Of the zonal and sub-zonal divisions generally recognised in the English Chalk, the following have been here identified:—

Zones.	Sub-Zones.
Belemnitella mucronata.	
Actinocamax quadratus.	
Marsupites testudinarius ...	Marsupites Band. / Uintacrinus Band.
Micraster coranguinum.	
Micraster cortestudinarium.	
Holaster planus.	
Terebratulina lata.	
Rhynchonella cuvieri	
Holaster subglobosus ...	Actinocamax plenus (at summit of zone).
Schloenbachia varians.	

Other divisions of sub-zonal rank, however, will be noticed in the sequel.

Existing knowledge of the features of the Chalk formation in this part of England is due mainly to the researches of Professor C. Barrois, Mr. William Hill, and Messrs. C. Griffith and R. M. Brydone.

Professor Barrois appears to have made a rapid traverse of the district along the line of the Meon Valley from East Meon to Soberton; passing thence to Portsdown, where he identified the Zone of *Belemnitella mucronata*. His notes relate chiefly to the latter area.

Mr. W. Hill visited some sections in the Lower and Middle Chalks near East Meon and Buriton about 1897, and a little information obtained by him was incorporated by Mr. A. J. Jukes-Browne in the second volume (1903) of his "Cretaceous Rocks of Britain," which also includes a few notes of observations made in the same neighbourhood by the officers of the Geological Survey who mapped or revised the geological boundaries on the six-inch scale.

The third volume of the "Cretaceous Rocks of Britain" (1904) includes a list of fossils from the neighbourhood of Clanfield, contributed by Messrs. C. Griffith and R. M. Brydone, whose brochure on "The Zones of the Chalk in Hants,"[1] published in 1911, furnishes a great deal of fresh information concerning sections in the Upper Chalk at Portsdown, and near the boundary of the Eocene Beds east and west of Bishop's Waltham.

Mr. Brydone's "Stratigraphy of the Chalk of Hants,"[2] which forms a kind of supplement to the last-named work, and which appeared while the present memoir was in hand, contains a zonally classified and annotated list of almost all the principal, and a great many of the minor, exposures of the Chalk in Hampshire (and in the Fareham district), illustrated by an excellent zonal map on the one-inch scale, and accompanied by palaeontological notes, remarks on structural features, &c.

Lists of fossils from four quarries in Portsdown and one near Butser Hill, with sketch-maps showing the position of the workings, are given in Mr. C. Griffith's "Geological Notes,"[3] also published in 1912.

As will be seen, the following account of the local Chalk embodies much information derived from the above-named sources.

Lower Chalk.

The district includes that part of the main outcrop in the South Downs which lies between Beacon Hill above Elstead and Old Winchester Hill near East Meon, together with an inlier, having an area of rather more than two square miles, in the Meon Valley between Exton and Warnford.

The so-called Chloritic Marl is about 3 feet thick. In its constituents it resembles the Selbornian greensand into which it passes, but the calcareous element is more strongly developed, seams and lenticles of brown-grey laminated marl being interbedded with the speckled glauconitic rock. This latter contains the usual angular and rounded phosphatic concretions, and is traversed by borings filled with marl of a lighter tint.

The Chloritic Marl passes up, in the space of a few inches, into an obscurely-laminated silty marl, which is succeeded by

[1] *London: Dulau & Co., Ltd.*, 1911. [2] *London: Dulau & Co., Ltd.*, 1912.
[3] *Winchester Coll. Nat. Hist. Soc.*, 1912. *Winchester: P. and G. Wells.*

indistinctly-bedded bluish marls with bands of marlstone acquiring a brownish tint, and revealing a roughly-laminated or shaly structure, on exposure to the weather. These bluish marls, which are fairly fossiliferous, are approximately coextensive with the Zone of *Schloenbachia varians*. They pass up into yellowish-white chalk with small rusty spots and nodules of marcasite of sub-spherical and sub-cylindrical forms. Massive bedding and curved jointing characterise this yellowish chalk, which is referred to the Zone of *Micraster subglobosus* on stratigraphical rather in palaeontological grounds, for distinctive fossils are remarkably scarce.

The top of the Lower Chalk is plainly marked by the "Belemnite," or *Actinocamax plenus*, Marls—a thin group of beds here comprising (or including) two bands of grey laminated marl, each about 1 foot thick, separated by a bed of firm white chalk about 4 feet thick. The marls are at present but poorly exposed, but have yielded a few examples of the characteristic belemnoid.

The thickness of the Lower Chalk near South Harting appears to be about 220 feet, of which rather more than half belongs to the Varians Zone.

Zone of Schloenbachia varians.

In the inlier near Exton the grey marls and marlstones of this zone are to be seen in the banks of the lane west of Gatcombe Farm, and in the cutting in the Meon Valley Railway south of that lane. In material removed from a well at Beaconhill Farm, a mile north of Exton Church, Mr. R. M. Brydone noted[1] *Rhynchonella mantelliana* J. de C. Sow., *R. martini* Mant., and *Baculitis baculoides* d'Orb.

Small exposures of the Chloritic Marl appear in road-banks north and north-west of Lower House Farm near East Meon (*see* above, p. 9). In a bared patch of yellowish flaggy marlstone, a few feet above the marl, the writer noted *Rhynchonella martini* Mant., *Kingena lima* Defr., and *Pecten* (*Syncyclonema*) *orbicularis* J. Sow.

The section of Chloritic Marl formerly to be seen north of Barrow Hill was noticed in the last chapter (p. 9). Another exposure, also now much obscured, was observed by Mr. W. Hill at the junction of two lanes 330 yards west-north-west of Twentyways Farm. "Here the bright greensand of the Upper Greensand is capped by a bed of hard concretionary masses, containing *Am.* [*Schloenb.*] *varians* and another species, and above this a pale grey very glauconitic marl is seen to pass up to Chalk Marl."[2]

Mr. Jukes-Browne states[3] that fragments of concretionary masses full of *Schloenbachia varians* were seen in hedgerows and ploughed land along the boundary of the Lower Chalk between this point and Buriton.

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[1] 'Stratigraphy of the Chalk of Hants,' 1912, p. 41.

[2] In Jukes-Browne's 'Cretaceous Rocks of Britain' (*Mem. Geol. Surv.*), vol. ii, 1903, p. 60.

[3] *Ibid., loc. cit.*

The upper part of the Chloritic Marl and its passage into the beds above are distinguishable in a road-bank and ditch north-west of the cross-roads a quarter of a mile north-west of Buriton Church.

Some of the upper beds of the Varians Zone are exposed in a disused quarry by the 15th milestone on the Portsmouth-Guildford road, north-west of Buriton. The quarry—about 50 feet deep—is much degraded, but shows at its northern end bluish, buff-mottled, marly chalk, with few fossils, passing up into firmer and lighter chalk in which casts of *Inoceramus crippsi* Mant., and of ammonoids (notably *Metacanthoplites rotomagensis* (Brong.) and *Calycoceras naviculare* (Mant.)) are abundant. Among other fossils found in the higher beds here were *Stephanophyllia bowerbanki* Edw. and Haime, *Rhynchonella martini* Mant., *Terebratulina striata* Dav., *Pleurotomaria perspectiva*? Mant., *Scaphites aequalis* J. Sow., *Turrilites scheuchzerianus* Bosc.[1]

Farther east, hard grey chalk with *Schloenbachia varians* was noted by Mr. C. E. Hawkins by the farm-road on the eastern side of Hemner Hill.

By the cross-ways at the north-western end of Torberry Hill an old quarry shows about 30 feet of bluish marl and marlstone, with the common *Rhynchonellae*, *Inoceramus crippsi* Mant., *Plicatula gurgitis* Pict. and Roux., overlain by about 40 feet of lighter greyish-yellow beds, containing masses of *Plocoscyphia maeandrina* Goldf., *Nautilus elegans* ? J. Sow., *Metacanthoplites rotomagensis* (Brong.). A well-preserved guard of *Belemnites ultimus* d'Orb, now in the British Museum (Natural History), was found about midway between the top and bottom of the section.

Bluish-grey marlstone, yielding *Discoidea cylindrica* (Lam.), *Inoceramus crippsi* Mant., &c., appears in the bank of the high road by the reservoir a quarter of a mile south of South Harting church; and the two species named, with *Rhynchonellae*, *Plicatula gurgitis*, and *Nautilus elegans* ?, were found in the lowest of the small road-side quarries on the northern face of Harting Hill.

From grey marly chalk, exposed in a quarry (now run down) on the north-western end of Beacon Hill, Mr. J. Rhodes (of the Geological Survey) collected 14 fossil species, including *Rhynchonella dimidiata* J. Sow., *Baculites baculoides* d'Orb., *Schloenbachia varians* (J. Sow.), and *Turrilites costatus* Lam.[2]

Zone of Holaster subglobosus.

Excellent sections, displaying almost the whole thickness of this zone, are to be seen near Buriton, in the quarries at the Lime Works south-west of the village, and on the eastern side of the Portsmouth-Guildford road about three-quarters of a mile to the north-west. These show from 60 to 80 feet or more of

[1] *See also* C. Griffith, 'Geological Notes,' *Winchester Coll. Nat. Hist. Soc.*, 1912, p. 32.

[2] 'Cretaceous Rocks of Britain' (*Mem. Geol. Surv.*), vol. ii, 1903, p. 66.

pale-yellowish and greyish-white chalk, mostly in massive, boldly-jointed beds, but in places a good deal shattered by earth movements. Nodules of more or less oxidised marcasite are common and often of large size. Excepting small, thick-shelled *Ostreae* (*O. vesicularis* (Lam.), *O. hippopodium* Nilss., &c.), and casts of borings and of little rod-like objects having a fascicular arrangement, fossils, as already remarked, are very scarce.

The same sort of chalk has been worked in a road-side pit below the contour of 400 feet on the northern slope of Harting Hill.

The group of beds forming the sub-zone of *Actinocamax plenus* is just distinguishable in the rubbly, grass-grown sides of the deep cutting in which the Portsmouth road crosses the crest of the South Downs east of Butser Hill. The descending succession there is:—

			Feet.
Melbourn Rock :		Hard, subnodular white chalk	seen, 2 to 3
Hol. Subglobosus Zone.	Act. plenus Subzone.	Light-grey laminated marly chalk ...	1
		Compact white chalk	about 4
		Light-grey laminated marly chalk ...	1
		passing into	
		Greyish chalk with faint marly streaks	—

A small exposure of the upper marl bed was seen at the south-eastern end of road-side quarry one furlong north-north-east of the Tower on Tower Hill, near South Harting.

The writer failed to find *Actinocamax plenus*, but Mr. R. M. Brydone records two examples from a section (now obscured) near the southern end of the cutting on the Meon Valley Railway east of Warnford Park. According to that author, the cutting referred to showed about 40 feet of Subglobosus Chalk below the Plenus Subzone, to which he assigns a thickness of 10 feet. The marls are still distinguishable at the northern end of the cutting, on the same railway, half a mile north-east of Meonstoke church.

CHAPTER V.

MIDDLE CHALK.

In the neighbourhood of South Harting, where conditions are favourable for the making of a close estimate, the thickness of this division appears to be about 200 feet; and this agrees with the measurement made by Mr. Brydone in the railway cutting (partly outside the area of Sheet 316) east of Warnford Park.[1]

The Zone of *Rhynchonella cuvieri*, about 70 feet thick, is composed largely of alternate beds of lumpy and nodular white chalk, 1 or 2 feet thick, and of thinner, fissile or roughly-laminated chalk, of pale greyish tint, and in many cases distinctly marly. Owing to this alternation, the Cuvieri Zone has a more obviously stratified appearance in section than any other part of the Chalk formation. In the few exposures of the junction with the Lower Chalk, the basal part of the Cuvieri Zone is a bed of firm sub-nodular white chalk, 2 to 4 feet thick, which rests with slight unevenness in the Plenus Marl. It is not clear whether this bed represents the whole, or only the lower part, of the Melbourn Rock of other districts. Some geologists probably would include part of the overlying chalk in the 'Melbourn Rock,' though it is difficult to see where, in that case, any satisfactory upper limit could be drawn. The fissile and nodular structures become less distinct upwards, and the highest beds, with those in the lower part of the succeeding zone, are mostly firm, homogeneous, white chalk.

The greater part of the *Terebratulina lata* Zone consists of white chalk with widely-spaced seams of light grey marl; but towards the top nodular bands occur, and the chalk, which becomes coarser in texture, assumes a light greyish tint. Here, too, flints become common: they are mostly small, elongate, and tapered; grey throughout, or with thick grey rinds. This zone appears to be about 120 to 130 feet thick.

The outcrops of Middle Chalk are confined to the northern part of the district. The mapping of an inlier at Stoughton, in the Ems Valley, is an error, probably due to certain hard beds (in the Zone of *Actinocamax quadratus*) having been mistaken for others at a much lower horizon.

Zone of Rhynchonella cuvieri.

Chalk with *Inoceramus labiatus* is exposed in the banks of the lane leading from Exton to Beacon Hill, at a spot one-fourth of a mile south-west of Exton church; also in the railway-cutting at Meonstoke.

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[1] 'Stratigraphy of the Chalk of Hants,' 1912, p. 37.

From the complete section of this zone, formerly exposed in the railway-cutting east of Warnford Park, Mr. Brydone records the following fossils:—*Bourgueticrinus*, *Discoidea dixoni* Forbes, *Hemiaster minimus* Agas., *Rhynchonella cuvieri* d'Orb., *Anomia papyracea* d'Orb., *Inoceramus labiatus* v. Schloth.

On Wether Down, south of East Meon, a recent road-side working by an old lime-kiln shows 12 feet of lumpy chalk with an ironstained conglomeratic band, about 6 inches thick, composed of pieces of firm chalk in a matrix of grey marl. *Inoceramus labiatus* is plentiful, and *Rhynchonella cuvieri* fairly common, in this section and in small exposures among the talus covering some older workings at a higher level hard by.

On the sides of the deep road-cutting east of Butser Hill, the 'Melbourn Rock' and some other hard beds higher in the zone stand out in slight relief from the grass-grown rubble. Above the lime-kilns east of the road by the northern end of this cutting a quarry exposes about 40 feet of alternating lumpy to nodular and greyish flaggy beds. The nodular structure is best developed in a conspicuous rusty bed, a foot thick, about one-third of the way up the section. Besides *Inoceramus labiatus*, which is abundant in the lower beds, the fossils noted include *Cidaris hirudo* Sorig., *Rhynchonella cuvieri* d'Orb., *Inoceramus lamarcki* Park., *Ostrea vesicularis* (Lam.).

A similar section to the last, also in the lower half of the zone, is given in the upper quarry at Buriton Lime Works, at the northern end of Heath Down.

The zonal base was observed by the high road on the northern slope of Tower Hill near Harting (*see* p. 14), while a few feet of beds with much *Inoceramus*, just above it, can be seen in small workings near the same spot, and to the south of Down Place, farther east.

Zone of Terebratulina lata.

The best exposures are situated in the inlying area of Middle Chalk around Exton.

To the east of Warnford Park, and again to the south-east of Meonstoke, the Meon Valley Railway runs through cuttings in white to greyish chalk with regular seams of grey marl. In the Warnford cutting, where the bedding dips northward at angles of 15° to 18° or 20°, *Terebratulina lata* Eth. and a few other fossils were got by the writer near the bridge by Hayden Barn, just north of the boundary of Sheet 316. Mr. R. M. Brydone,[1] who records *Conulus subrotundus* Mant., from this section, refers 126 feet of the beds there exposed to the Terebratulina Zone, but with some doubt as to the exact position of the lower zonal limit, which is usually difficult to determine in inland exposures.

The highest beds, dipping about 5° a little west of south, appear in the Meonstoke cutting near the Rectory, but a more practicable section of these exists to the west of Exton, by the

[1] *Op. cit.*, pp. 36, 37, 46.

side of the road to Beacon Hill, at the spot where a southward dip of 2° is marked on the map. The descending succession in a small quarry here is:—

		Feet.
Zone of *Hol. planus.*	3. White chalk; coarse, firm to hard, and sub-nodular in places. A few small flints (like those below) at the base ... ... seen	8
Zone of *Terebratulina lata.*	2. Grey laminated marl, with thin lenticles and rolled pieces of white chalk...	0½
	1. Greyish chalk; coarse and with ill-defined bands of nodular yellowish, ironstained chalk, the highest and most distinct of which is between 2 and 3 feet from the top. Scattered thick-rinded flints, mostly small, grey, and elongate ... ... seen	15

Bed (1) is notably fossiliferous in its higher part, *Inoceramus lamarcki* Park. (including *I. brongniarti* J. de C. Sow.), *Ostrea vesicularis* (Lam.), and the brachiopods *Rhynchonella plicatilis* (J. Sow.), *Terebratula semiglobosa* J. Sow., and *Terebratulina lata* Eth., being particularly common. Some of the yellowish nodules here are encrusted with small *Ostreae* and *Spondylus latus* (J. Sow.). Other fossils noted include:—*Camerospongia subrotunda* (Mant.), *Bourguetiericrinus ellipticus* (Miller) (very small ossicles), *Discoidea dixoni* Forbes, *Serpula ampullacea* J. de C. Sow., *Rhynchonella reedensis* Eth., *Lima* (*Plagiostoma*) *hoperi* Mant., *Spondylus spinosus* (J. Sow.), and *Scaphites* cf. *geinitzi* d'Orb. The occurrence of the last-named is noteworthy, as *S. geinitzi* d'Orb., which it closely resembles, is rarely met with outside the Subzone of *Heteroceras reussianum*. The single example found was got from the highest yellow nodular bed, 3 feet below the marl-seam (2); and though this part of the section was examined closely on two occasions nothing else suggestive of a higher zone than that of *Terebratulina lata* was encountered.

The marl seam (2) and the chalk immediately above and below it, contain numerous moulds of slightly-curved borings, about 10·25 millimeters in diameter.

The white chalk (3) at the top of the pit is badly placed for examination, and yielded only *Ventriculites radiatus* Mant., *Holaster planus* (Mant.), *Terebratula semiglobosa* J. Sow., *Inoceramus labiatus* var. *latus* J. de C. Sow., and *Ostreae*.

Bed (1) of this section is traceable in road-side exposures for a distance of 200 yards up the slope north of the quarry.

On the main outcrop south of East Meon there are small openings just south of Upper Barns and west of the Roman Camp.

Half a mile west-north-west of East Meon an almost degraded pit above the high road to Drayton shows a little white chalk containing few scattered flints and a strongly-marked ironstained nodular bed, 9 inches thick, with a seam of grey marl immediately above it. The nodular bed is traversed by borings filled with iron oxide, which replaces the calcite in some of the fossils. These last are scarce, but Mr. Brydone[1] records *Terebratulina lata* (“‘*gracilis*’”) and *Conulus subrotundus*; to which the

[1] *Op. cit.*, p. 98.

writer can add *Plocoscyphia convoluta* (T. Smith), *Cidaris hirudo* Sorig., *Terebratula semiglobosa* J. Sow., and *Ostrea vesicularis* (Lam.). The true dip appears to be about 10° north

Chalk in this zone was worked in the large disused quarry near the upper end of the Portsmouth-road cutting east of Butser Hill, and is recognisable also in a bank of the same road opposite the house which was formerly the "Coach and Horses" inn, north-east of Clanfield.

The only other exposure known to the writer is in a little pit near the crest of the Chalk escarpment at Harting Hill, a few yards south-east of the spot where the road from South Harting is joined by that leading up from Turkey Island and Down Place. This shows a few square yards of coarse-grained firm white chalk, with small flints like those in the Exton section, described above. The brachiopods *Rhynchonella plicatilis* J. Sow., *R. reedensis* Eth., and *Terebratula semiglobosa* J. Sow., are very freely scattered through the small thickness (about 3 feet) of chalk exposed. The associated fossils noted include—*Camerospongia subrotunda* (Mant.), *Parasmilia centralis* (Mant.), *Cyphosoma radiatum* Sorig., *Terebratulina lata* Eth., *Inoceramus lamarcki* Park., *Lima* (*Limatula*) *decussata* Goldf., *Plicatula barroisi* Peron, *Pollicipes glaber* F. A. Roemer. This chalk is close to the lower limit of the *Holaster planus* Zone, and the writer is by no means sure that it does not belong to that division of the Upper Chalk.

CHAPTER VI.

UPPER CHALK.

In the southern part of the district, where it is most fully developed, this division is probably about 750 feet thick, and is therefore by far the thickest of the Upper Cretaceous stages distinguished on the map.

As was noted in the introductory portion of Chapter IV., the Upper Chalk here comprises six zones, namely those from *Holaster planus* to *Belemnitella mucronata*, inclusive. Owing, however, to erosion in early Eocene times, the greater part of the last-named zone, as developed in the Isle of Wight and, more fully, in Norfolk, is missing.

North of the main mass of the Eocene strata the zonal outcrops traverse the district from west to east in irregular but broadly parallel belts, which expand slightly eastward with the concurrent decrease in the prevailing southward dip of the bedding. The Upper Chalk of Portsdown, and of the coast plain south and east of that ridge, is part of an inlier brought up by an anticlinal fold of post-Eocene date (*see* Fig. 2, p. 26).

The Zone of *Holaster planus* is composed of white to greyish chalk, varying much in hardness, and possessing a lumpy to distinctly nodular structure. The texture is coarse. Ill-defined wavy streaks of grey, gritty marl are noticeable in the more nodular beds, where the lumps of hard chalk commonly have a fibrous appearance. Flints are common and mostly of small size, with thick grey rinds. The Sub-zone of *Heteroceras reussianum* has not been recognised, and the Chalk Rock often developed at that horizon is wanting.

Of the Zone of *Micraster cortestudinarium*, little is here to be seen. Its chalk resembles that of the zone below, but is, on the whole, whiter and less nodular; and it contains more and larger flints, which occur partly in definite courses. Mr. Brydone's[1] estimate of the combined thickness of the Cortestudinarium and Planus Zones at Warnford is 112 feet, which agrees with Dr. A. W. Rowe's measurement in the Isle of Wight, where the lower of these two zones is approximately 60 feet thick.

In the Zone of *Micraster coranguinum*, which is 226 feet at Warnford,[2] bands of firm sub-nodular character, more or less ironstained, occur in the lower part, and less frequently above, but the bulk of the chalk is soft and white, and of a texture ranging from rather coarse near the base to very fine at the top. Flints abound, in regular courses of nodules, and in tabular seams. There is a remarkable paucity of good sections in this thick and elsewhere much-quarried zone.

The exposures of the *Marsupites testudinarius* Zone, too, are miserably inadequate. Compared with the zone below, its salient lithological features are, the softness and fineness of its chalk, and the fewness of its flints. These last, as far as can be seen, are

[1] 'Stratigraphy of the Chalk of Hants,' 1912, p. 37. [2] Brydone, *loc. cit.*

normally of small size, thick-rinded, and devoid of strongly-marked projections. Small almond-shaped nodules and tabular lenticles of grey flint are rather common in the upper beds, as in many localities outside this district. The Uintacrinus and Marsupites Bands are both recognisable, and each is probably about 35 to 40 feet thick—leaving out of account the debateable passage-beds (probably about 20 feet thick) above the latter band, which are referred by Dr. A. W. Rowe[1] to the Marsupites Zone, and by Messrs. C. Griffith and R. M. Brydone[2] to the zone above.

The succeeding Zones of *Actinocamax quadratus* and *Belemnitella mucronata* will be dealt with in the next chapter.

Zone of Holaster planus.

A few feet of chalk with *Holaster planus* Mant. is seen above the marl-seam regarded as the upper limit of the Terebratulina Zone in the quarry west of Exton, described above (p. 17).

Small bared patches of lumpy chalk with the same echinid were noted in a road-bank half a mile south-east of Meonstoke church; and Mr. Brydone[3] also records this fossil, with *Micraster leskei* Desm., from the adjacent railway-cutting.

Other exposures, yielding a few distinctive fossils, are noted by Mr. Brydone at the southern end of Hayden Copse, 5 furlongs north-east of Peake Farm, and in the road-cutting near the top of Teglease Down, south-east of Old Winchester Hill.

Excepting some rubbly patches on Greenbourne Down near Butser Hill, and by the 13th milestone on the Portsmouth-Guildford road, the writer knows of only one more exposure of the Planus Beds within the area of Sheet 316. This is a very small degraded digging on the crest of Harting Hill, south-east of, and about 10 to 15 feet higher than, the pit noticed on p. 18. The lumpy chalk here is richly fossiliferous, and though in a bad condition for collecting, yielded in the space of a few minutes some 16 fossil species, including *Ventriculites mammillaris* T. Smith, *Axogaster cretacea* Lonsd., *Holaster planus* Mant., *Micraster praecursor* Rowe, the common *Terebratulae, Cardita* ? *Inoceramus labiatus* var. *latus* J. de C. Sow., *Lima* (*Plagiostoma*) *hoperi* Mant., *Spondyli*, *Plicatula barroisi* Peron, and *Pollicipes glaber* F. A. Roemer. This chalk probably belongs to the lower part of the Planus Zone.

Zone of Micraster cortestudinarium.

The best exposure appears to be that in the road-cutting by the entrance-yard at Droxford Station on the Meon Valley Railway, one-third of a mile north-east of Droxford church. The cutting is a good deal run-down and grassed, but would repay a closer inspection than the writer was able to give it. The fossils seen were—*Serpula cincta* Goldf., *Micraster cortestudinarium* (Goldf.), *Inoceramus* (thick fragments), *Ostreae*.

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[1] 'Zones of the White Chalk, &c.' *Proc. Geol. Assoc.*, vol. xvi (1900), p. 338.
[2] 'Zones of the Chalk in Hants,' 1911, pp. 4 to 9.
[3] 'Stratigraphy of the Chalk of Hants,' 1912, p. 49.

Mr. Brydone[1] notes the first two of the above fossils from a pit west of the tumuli on Teglease Down, and *Holaster placenta* Agas. in a pit on the crest of the down between Hyden Hill and Tegdown Hill, south of East Meon.

Zone of Micraster coranguinum.

Beginning on the west, there are small showings of blotchy chalk with *Inoceramus lamarcki* var. *cuvieri* J. de C. Sow. in banks by the cross-roads south-south-west of Lower Preshaw.

On Corhampton Down, a shallow working 300 yards north-east of Franklin Farm is in soft chalk with few thick-rinded flints. Fossils:—*Pharetrospongia strahani* Sollas, *Bourgueticrinus ellipticus* (Miller), *Conulus albogalerus* Leske, *Micraster coranguinum* (Leske). Similar chalk appears in a road-bank on the north side of the workhouse at Droxford.

The cuttings on the Meon Valley Railway between Brockbridge and the northern end of Soberton are in this zone; and farther east there are several exposures of little interest in the parishes of Soberton and Hambledon,[2] *e.g.*, at Chidden Holt; north-east of Park House; and south-south-west of Stoneridge Farm. The pit at Chidden Holt (where a dip of 5° SSW. is marked on the map) is now degraded, but fossils are fairly plentiful in the blocks of chalk on the talus.

At the southern end of Ditchacre Copse, north-east of Clanfield, an overgrown dell shows a little lumpy ironstained chalk with rough and spongeous flints. To judge from the basal ornamentation of an imperfect example of *Micraster cortestudinarium* (Goldf.) found by the writer, Messrs. Griffith and Brydone[3] are right in referring this chalk to the lower part of the Coranguinum Zone, as defined by Dr. Rowe.

A roadside digging 5 furlongs west-north-west of Old Farm, Chalton, shows 2 feet of firm blocky chalk with violet flints and much broken *Inoceramus*. Other poor exposures of chalk in the upper part of the zone were noted in road-banks north-west of Compton.

At a quarter of a mile north-west of the church at North Marden there are small wayside workings in firm to hard, subnodular, rusty chalk, containing numerous rough, pitted flints of elongate form and with thick grey rinds. This chalk—probably about the middle of the zone—is noticeably fossiliferous, *Echinocorys scutatus* Leske (ovate) and Bryozoa being common. Other fossils observed include—*Pharetrospongia strahani* Sollas, *Stauranderaster ocellatus* (Forbes), *Cidaris perornata* Forbes, *Micraster coranguinum* (Leske), *Pecten* (*Chlamys*) *cretosus* Defrance.

Zone of Marsupites testudinarius.

Though the Uintacrinus Band doubtless has a continuous outcrop across the northern part of this area, from Beech Grove near Upham on the west to East Marden on the east, no exposures have

[1] *Op. cit.*, p. 50.
[2] 'R. M. Brydone gives a list of these, *op. cit.* p. 70. Nos. 559–567.
[3] 'Zones of the Chalk in Hants,' 1911, p. 15.

been observed westward of the River Meon. East of that stream, Mr. Brydone[1] identifies this subzone in five places, namely, in the railway cutting south of Cut Bridge road (west of the church) at Soberton; in banks south-west and south-east of Greenfield Copse; in a pit about one mile north-north-west of Hambledon church; and in a lane-bank 150 yards south-east of Park House, north-east of Hambledon.

East of Park House no other openings are seen short of Compton, where the banks of the lane south of the church afford poor exposures of soft white chalk, with faint greyish venules in places. Plates of *Uintacrinus* are fairly plentiful, and are associated, as usual, with *Bourgueticrinus ellipticus* (Miller) and *Ostrea vesicularis* (Lam.).

The westernmost exposure of chalk referable to the Marsupites Band is in a small working one-third of a mile south-east of Green Hill, north of Upham, and from which Mr. Brydone[2] records the name-crinoid and *Echinocorys scutatus* Leske (of the characteristic pyramidate form which he names "var. *elevatus*").

A pit at the rifle-butts 300 yards south-south-west of Dean Farm, in the combe east of Stephen's Castle Down, shows 4 feet of soft chalk (with few scattered flints) in which *Marsupites testudinarius* v. Schloth. is common and associated with *Bourgueticrinus*, *Echinocorys scutatus* Leske, *Pecten cretosus* Defr., *Spondylus latus* (J. Sow.), &c.

A section of the passage-beds between the Marsupites and Quadratus Zones, seen in the northern of two quarries south-east of the church at Soberton, will be noticed more fully in the next chapter (p. 31).

Passing over a small opening near the 300 feet contour three-quarters of a mile east of Soberton cross-roads, the next exposure of interest is that in a pit in the north-western slope of Windmill Hill, near Clanfield—indicated on the map by the words "*Fossils: Marsupites.*" The face of this excavation is at present entirely hidden by talus, on which one notices the débris of a band or bands of hard, ironstained chalk with green and brown nodules to which small *Ostreae* adhere. *Echinocorys scutatus* Leske, of bluntly pyramidate shape, Asteroidea, *Rhynchonella plicatilis* (J. Sow.), and *Ostrea vesicularis* (Lam.) are the most conspicuous fossils. Mr. Jukes-Browne[3] records 28 species from this pit, including *Septifer lineatus* (J. de C. Sow.), *Actinocamax granulatus* (de Blainv.) and *Lamna appendiculata* Agassiz. A horizon near the upper limit of the range of *Marsupites* is indicated.

Parts of the Marsupites Band can be seen in the banks of the lane east of Compton church, ornate plates of the name-crinoid being abundant at a point 22 paces from the southern end of that lane, and about 40 feet higher than the exposures of Uintacrinus Chalk in the lane south of the church, mentioned above.

A small, oval inlier of the higher beds of the zone is inferred to exist on the southern slope of Portsdown, about Wymering and Paul's Grove.

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[1] 'Stratigraphy of the Chalk of Hants,' p. 79. [2] *Op. cit.*, p. 87.

[3] 'Cretaceous Rocks of Britain' (*Mem. Geol. Surv.*), vol. iii, 1904, pp. 65–68: from information furnished by C. Griffith and R. M. Brydone.

CHAPTER VII.

UPPER CHALK—*continued.*

The present chapter is concerned with the Zones of *Actinocamax quadratus* and *Belemnitella mucronata*. These divisions of the Chalk have been extensively quarried for agricultural and other purposes, and there is no lack of good sections in them. The Zone of *Actinocamax quadratus*, which is about 300 feet thick, begins below with soft white chalk, holding comparatively few, scattered flints, and hardly distinguishable from that of the Marsupites Zone. Above this, and forming the bulk of the zone, comes a series of beds in which homogeneous white chalk alternates, at intervals of a few inches to a few feet, with obscurely laminated chalk, exhibiting a faint greyish tint. There are also frequent distinctly grey seams and partings of a marly nature. Flint-nodules occur freely in numerous single courses, and in bands where they are more or less thickly sown. Tabular flint also is common, mostly in oblique veins.

In the upper part of the zone the greyish beds die out, or become less distinct. The flint-courses continue to be plainly marked, and increase in frequency towards the upper zonal limit: as a rule they follow the general bedding, but in a section at Downend, near Farcham, oblique and curved courses of nodular flint are seen in this part of the Quadratus Chalk (Fig. 5. p. 29).

As a rule, the flints of this zone have rather thick rinds and pale yellowish to pinkish surfaces, but nodules almost devoid of cortex are common, especially in the highest beds. Small grey flints of subspherical and subcylindrical shapes occur throughout. Some of the latter type outwardly resemble the horned and tapered nodules of the Terebratulina and Planus Zones, though they differ from these in the texture of their rinds, which are compact and porcellanous, whereas in the case of the two zones just named the flint-rinds usually resemble earthenware.

Mention should be made of the inconstant bands of ironstained chalk which occur at various horizons in this zone. Many of these possess a lumpy structure; some are truly nodular; and a few of the latter sort have a layer of small green nodules at the top. The more markedly nodular bands form part of undefined bodies (one cannot say beds) of chalk, some obscure abnormality in whose constitution or mode of formation is expressed by a local absence or scarcity of flints.

In Hampshire, Messrs. Griffith and Brydone[1] distinguish three divisions of the Quadratus Zone—or, to be precise, three divisions of that part of the Chalk which lies between the beds actually containing *Marsupites testudinarius* and the base of the *Belemnitella mucronata* Zone; for these authors include in the Quadratus Zone some 20 to 25 feet of beds that belong to the Marsupites Zone as defined by Dr. A. W. Rowe.

[1] 'Zones of the Chalk in Hants,' 1911, pp. 3–6. Also Brydone, 'Stratigraphy of the Chalk of Hants,' 1912, pp. 10–15.

The lowest of their three divisions—the "Subzone of *Echinocorys scutatus* var. *depressus*"—is about 60 feet thick. It is characterised by a depressed form of *Echinocorys* (which seems to be confined to the middle 20 feet of the subzone), by a variety of *Bourgueticrinus*, and by the first appearance of free unilamellate specimens of *Cribrilina gregoryi* Brydone. *Offaster pilula* (Lam.) occurs but sparingly in this division.

To their second division, or "Subzone of *Offaster pilula*," Messrs. Griffith and Brydone assign about 45 feet, "rather below the middle of the zone." The name-fossil is common throughout, and especially so in two belts, each 12 to 15 feet thick, situated respectively at the top and bottom of this subzone. In the upper belt, *Offaster pilula* attains a greater size than elsewhere; in the lower belt this echinid is invariably associated with a small, truncated form of *Echinocorys scutatus* (the var. *truncatus* Griffith and Brydone). Certain other fossils, such as the striate *Ostrea lateralis* Nilsson, not restricted to this subzone, are usually more abundant here than at higher or lower horizons. The third and highest division, or "Subzone of *Actinocamax quadratus*," comprises the remaining 200 feet (or thereabouts) of the Quadratus Zone. Much of this is but poorly fossiliferous. The characteristic faunule includes the name-fossil, a dwarf form of *Offaster pilula* (Lam.), and some varieties of *Bourgueticrinus ellipticus* (Miller).

In his lately-published "Stratigraphy of the Chalk of Hants," Mr. Brydone raises the "Subzone of *Actinocamax quadratus*" to full zonal rank, and creates a new "Zone of *Offaster pilula*" to cover the two lower subzones—a course advocated a few months previously by Mr. Jukes-Browne.[1] The substitution of zones for subzones of the same name is rather confusing, but the nature of the proposed changes, and the relation of the new classification to that in common use, will be more readily comprehended by reference to the subjoined comparative table, in which the dotted cross-rules represent definite stratigraphic horizons.

<table>
<tr><th>1.
A. W. Rowe, 1900 (and Geological Survey).</th><th colspan="2">2
Griffith and Brydone, 1911.</th><th colspan="2">3.
R. M. Brydone, 1912.</th></tr>
<tr><td rowspan="2">Zone of Act. quadratus.</td><td rowspan="3">Zone of Act. quadratus.</td><td>Subzone of Act. quadratus.</td><td colspan="2">Zone of Act. quadratus.</td></tr>
<tr><td>Subzone of Offaster pilula.</td><td rowspan="2">Zone of Offaster pilula.</td><td>Subzone of Offaster pilula.</td></tr>
<tr><td>Zone of Marsupites.</td><td>Subzone of Echinocorys depressus.</td><td>Subzone of Echinocorys depressus.</td></tr>
</table>

[1] 'On the Recognition of Two Stages in the Upper Chalk,' *Geol. Mag.*, 1912, p. 372.

The present writer can testify to the local value of the subzonal divisions made by Messrs. Griffith and Brydone, but it remains to be seen how far the zonal classification employed by the latter author, and by Mr. Jukes-Browne, is applicable in other parts of the country. In the meantime, having regard both to the possibility of that classification being generally adopted in the future, and to the seeming lack of exposures of the junction of the Marsupites and Quadratus Zones of Dr. Rowe in the area of the Fareham map, it is deemed advisable here to use the term '*Actinocamax quadratus* Zone' in the sense indicated in the second column of the above table.

The Zone of *Belemnitella mucronata* has its chief development in the vicinity of Fareham, where there appears to be room for about 60 to 70 feet of it between the Quadratus Zone and the base of the Eocene. The chalk, mostly pure white and soft, contains regular seams of grey marl. Two such marly seams, 1 to 1½ feet apart, occur with much persistence at or a little above the base of the zone, and as they are separated from other seams of a like nature above and below by a considerable thickness of white chalk, they form a valuable guide to that horizon. Flints occur in numerous courses wherein the nodules are often rather widely spaced. Their rinds are either very thin, or moderately thick and banded like agate. Here and there the nodules are run together into stout masses, 1½ feet or more in diameter.

Zone of Actinocamax quadratus.

This zone appears in two distinct areas. The northern or main outcrop, varying in width from 1 to 5 miles, ranges across the district from the neighbourhood of Upham on the west to that of Stoughton on the east. The southern outcrop, forming part of a large inlier, embraces much of Portsdown and of the strip of coastal plain eastward of Porchester and south of the high road through Havant and Emsworth. It will be convenient to deal first with the latter area.

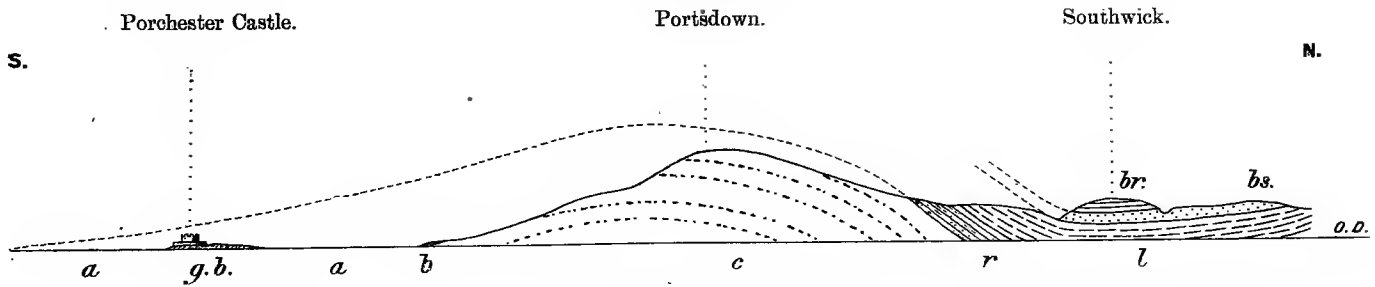
Southern Outcrop.—As all the exposures of consequence are in Portsdown, and afford among them an almost complete section of the zone, they will be noticed, as far as possible, in stratigraphical order, beginning with those of the lowest beds.

The oldest chalk at present visible in Portsdown is that at the bottom of the lower working in the great quarry half a mile north of Paul's Grove. The lower working is sunk in the floor of the upper one, and the face of the step between them shows 20 to 25 feet of soft, white, boldly jointed chalk with thinly-scattered flint-nodules and seams of tabular flint. The presence of small sub-pyramidate and depressed forms of *Echinocorys scutatus* Leske, and of *Micraster cruciatus* (Leske), coupled with the absence or scarcity of *Offaster pilula* (which is common above), point to the lower part of the Quadratus Zone. Messrs. Griffith and Brydone, who refer this chalk to their *Echinocorys depressus* Subzone, recognise the same division in the lower part of a disused quarry half a mile north of Wymering.

The higher and by far the greater part of the Paul's Grove section comprises something like 100 feet of distinctly-stratified chalk with frequent marly seams and flint-courses, both becoming more numerous towards the top of the quarry. The middle beds (of the entire section), accessible from the upper floor of the quarry, are generally rich in small fossils: weathered

FIG. 2.—*Section from Porchester Castle to Southwick.*

Distance, 3½ miles. Vertical scale exaggerated.



Superficial { *a.* Alluvium. *b.* Brickearth. *g.* Gravel.

Eocene { *br.* Bracklesham Beds. *bs.* Bagshot Sands. *l.* London Clay. *r.* Reading Beds

Cretaceous : *c.* Upper Chalk.

surfaces in many places are rough with projecting *Porosphaerae*, Asteroid ossicles, Bryozoa, *Ostreae*, &c. Examples of *Echinocorys scutatus* Leske, *Offaster pilula* (Lam.), and *Cribrilina gregoryi* Brydone are common; and among other noteworthy fossils observed are *Coelosmilia laxa* Edw. & Haime, *Serpula ilium* Goldf., *S. turbinella* J. de C. Sow., *Eschara acis* d'Orb., and *Vincularia santonensis* d'Orbigny. These *Offaster pilula* Beds, which may be about 50 feet thick, have been identified by Griffith and Brydone in the quarry north of Wymering mentioned above, and in smaller workings respectively one-third of a mile north of the cross-roads at Drayton, and a little more than a quarter of a mile west-north-west of Farlington church, though in the last two exposures distinctive fossils seem scarce.

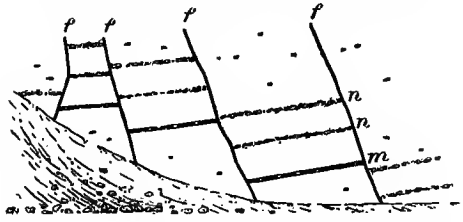
Chalk referable to this subzone is exposed in the low banks of a little-used cross-road (not marked on the map) between 4 and 5 furlongs north of Wymering. It contains rusty beds or lenses of coarse, lumpy character, in which organic remains are fairly plentiful. The most fossiliferous of these ironstained bands observed is 85 paces south-east of the point where the road in question meets the 'ridge-way' along the crest of Portsdown. Among the fossils noted were *Porosphaera patelliformis* Hinde (of large size), *Parasmilia* cf. *mantelli* Edw. & Haime, *Bourgueticrinus ellipticus* Miller ("form 2" Griffith & Brydone), *Cidaris subvesiculosa* d'Orb., *Offaster pilula* (Lam.), *Lima sp.*, *Pecten* (*Neithea*) *quinquecostatus* J. Sow., *Pollicipes glaber* F. A. Roemer.

The remaining sections of Quadratus Chalk in the Portsdown area are in the highest of the three subzones—that of *Actinocamax quadratus*.

The upper part of the Paul's Grove section is out of reach, but it is highly probable that some of the beds there seen are represented in the group of quarries, now used as tea-gardens, by the Portsmouth-Guildford road north-east of Cosham; which quarries, with the adjacent road-cuttings by the "George" inn, show upwards of 60 feet of chalk with regular courses of flints. Megascopic fossils—other than *Porosphaerae*, and *Echinocorys scutatus* Leske (of rather tall gibbous form)—are comparatively scarce, but Mr. R. M. Brydone states (*in lit.*) that *Actinocamax quadratus* (Defr.) has been observed in the tea-gardens west of the high road.

FIG. 3.—*Step-faults in the Chalk, Porchester.*

Vertical scale, about 1 inch = 16 feet.



f f. Faults, *m*. Marl-seam, *n n*. Nodular bands.

The ascending sequence seems to be continued, though perhaps with some overlap, in two roadside quarries, less than 50 yards apart, about one-third of a mile north-north-west of Porchester railway-station. In the eastern working, which shows about 25 feet of beds much stained by iron oxide, the flints are few and scattered, but the stratification is well brought out by bands of yellow and green nodular chalk, forming with an associated seam of grey marl a striking group, not observed elsewhere in the district. A series of little faults adds to the abnormal appearance of the section, part of which is diagrammatically rendered in fig. 3. Besides the two nodular bands indicated in the figure, there are several others less distinct. Fossils are not common; the few noted by the writer

include—*Bourgueticrinus ellipticus* (Miller) (' form 3 ' Griffith & Brydone), *Pyrinaster angustatus* (Forbes), *Echinocorys scutatus* Leske of large, pyramidate-gibbous type.

The western quarry shows about 40 feet of newer beds, which immediately succeed those just described. Flints are abundant and occur in well-defined courses. A rough cleavage is developed in the chalk along belts intersecting the planes of bedding (see p. 65). A list of 50 fossil species collected by Dr. A. W. Rowe[1] from the upper part of the Quadratus Zone north of Porchester (and presumably from this quarry) includes — *Cyphosoma spatuliferum* Forbes, *Salenia geometrica* Agas., *Offaster pilula* (Lam.) small, *Echinocorys scutatus* Leske, mostly gibbous, some subpyramidate, *Lunulites cretaceus* Defr., *Rhynchonella limbata* v. Schlot.

The Portsdown area, including the tract west of Wallington River, affords several good openings in the highest beds of the zone, but for most of these a bare enumeration must suffice.

At Bedhampton, the Lime Works quarry, a quarter of a mile west of the church, shows soft white chalk to a thickness of 84 feet, according to a measurement made by Messrs. Griffith and Brydone[2] some years ago. There are approximately 20 well-marked tabular and nodular flint-courses, the intervals between which range from 2 or 3 feet in the upper third of the section to about 12 feet in the lower third. Tabular flint is well developed along two sets of parallel planes—one agreeable with the bedding, the other disposed at a high angle thereto. A ladder-like arrangement of the two sets, roughly represented in figure 4, was observed on the southern face of the quarry in 1912.

FIG. 4.—*Arrangement of Tabular Flints, Bedhampton.*

Scale : 1 inch = 4 feet.

In the lower half of the section fossils are notably scarce, the only significant form seen by the writer being gibbous *Echinocorys scutatus* Leske. In the upper half *Porosphaerae*, Bryozoa, and *Serpulae* are common; and among the more characteristic fossils found here are—*Bourgueticrinus ellipticus* (Miller) ' form 4 ' Griffith & Brydone, *Offaster pilula* (Lam.) dwarf, and *Actinocamax quadrotus* (Defr).[3]

The ascending sequence within the Quadratus Zone is continued and ended in the road-cutting above and immediately north of the Bedhampton quarry. Here a small face about 10 feet high, on the north side of the roadway, shows the two thin beds or seams of grey marly chalk, 1 foot apart (fig. 6, p. 33), which Messrs. Griffith and Brydone adopted as the base of the *Belemnitella mucronata* Zone in 1911.[4] In the few feet

[1] In 1908. MS. note. [2] 'Zones of the Chalk in Hants,' 1911, p. 4.

[3] The last recorded by Griffith & Brydone, *loc. cit.*

[4] *Op. cit.*, p. 5. Mr. Brydone has since stated ('Stratigraphy of the Chalk of Hants,' 1912, p. 8) that he is "strongly inclined" to place the base of the Mucronata Zone at a horizon about 20 feet lower, *i.e.*, at a single marl-seam 17 feet below the top of the adjacent Bedhampton Lime-works section. The only palaeontological ground assigned for this alteration is the occurrence of *Belemnitella mucronata*, in small numbers, below the "paired marl seams" which he and Mr. Griffith previously regarded as the common limit of the Mucronata and Quadratus Zones in the Portsdown area. But, as Mr. Brydone himself points out in the same work (p. 10), *Belemnitella mucronata* is not infallible as a zonal guide, inasmuch as it is met with in the highest beds of the Quadratus Zone in other parts of the country; and in his account of two junction sections at Downend (Nos. 1153, 1166, p. 9) he proposes to draw the base-line of the Mucronata Zone at a horizon which is not only (21 feet) above the known lower limit of the range of *Belemnitella mucronata*, but also (9 feet) above a bed which he tentatively correlates with "paired marl seams" above mentioned.

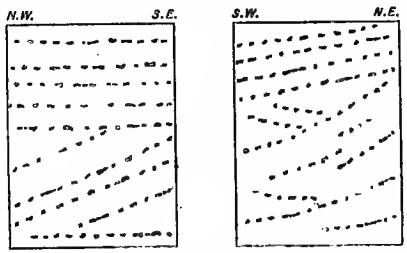
These two marl seams form so convenient a base for the Mucronata Zone in Portsdown that they ought not to be lightly abandoned.

of chalk seen beneath the marls the scattered flints have very thin white cortices. Small fossils are common, and include—*Porosphaerae, Bourgueticrinus ellipticus* (Miller) ' form 4 ' Griffith & Brydone, Asteroidea, *Cidaris subvesiculosa* d'Orb. Noteworthy among the asteroids are the large pad-like ossicles of *Stauranderaster senoniensis* (Valette), which the writer noticed at about the same horizon in two other sections in Portsdown.

Other exposures of the highest beds of the Quadratus Zone are to be seen in the following places:—(1) the trench of Farlington Redoubt (on all sides but the north), a mile west of Bedhampton church; (2) old pit a quarter of a mile east of Portsdown Cottage, Cosham; (3) quarry south of Offwell Farm; (4) quarry north-east of Albany Farm; (5) quarry east of the ' Old Vine ' inn, a quarter of a mile north-north-west of Albany Farm; (6) Clapper Hill quarry (north face) a furlong west-south-west of Downburn, Wallington; (7) Water Works quarry, Wallington; (8) ? quarry by the railway 300 yards north-east of Downend House, east of Fareham[1]; (9) Messrs. Rogers and Sons' Whiting Works, nearly half a mile north-east of Downend House; and (10) Fontley Dell, a quarter of a mile east of Great Fontley Farm. Of these, numbers 1, 3, 6, 7, 8 and 9 show some of the lowest beds of the Mucronata Zone. No. 9 alone will receive further attention here, but some of the others will be referred to again, under the succeeding zonal heading.

At the Whiting Works chalk is quarried in a narrow, inclined excavation which, in the summer of 1912, was stated to be 104 feet deep at its

FIG. 5.—*Normal and Oblique Bedding in the Chalk, Downend, Portsdown.*



northern end. A pronounced south-westward dip of about 10° brings about 40 feet of beds referable to the Mucronata Zone into the southern part of the working. In these beds, and in the highest of the Quadratus Beds below them, the numerous courses of flint-nodules display the usual parallelism, but in the middle and lower parts of the section they are strangely divergent and confused, their arrangement in places being suggestive of current-bedding on a large scale[2] (fig. 5).

A persistent marl-seam (the most conspicuous in the section) having in places an indistinct seam of a similar character 1½ feet above it, marks approximately the junction of the two zones. The Quadratus Beds contain lenses of firm to hard, yellowish, iron-stained chalk, in one of which—immediately below the persistent marl-seam just mentioned, on the eastern side of the quarry—cavities lined with crystals of calcite and moulds of sponge-spicules were noted. The fossils observed by the writer there and in the normal chalk close below the same marl-seam in other parts of the section included — *Stauranderaster senoniensis* (Valette), *S. ocellatus* (Forbes) and other Asteroidea, *Echinocorys scutatus* Leske (tall gibbous), *Serpula plexus* J. de C. Sow. (very common), *Rhynchonella limbata* (v. Schloth.), *R. plicatilis* (J. Sow.), small *Ostreae*, also very common. No examples of *Actinocamax quadratus* were seen, but this belemnoid is

[1] *See* footnote 2, p. 34.

[2] R. M. Brydone (*op. cit.*, pp. 8, 9) is probably mistaken in attributing this phenomenon to tectonic causes, but his account of the section is difficult to follow, and since its publication the present writer has had no opportunity to revisit the quarry.

stated to be fairly common in the lower part of the section, and even to occur "regularly" up to a few feet above the marl-seam here adopted as the upper limit of the Quadratus Zone, thus overlapping *Belemnitella mucronata*, which is said to extend to about 12 feet below that horizon.[1]

In the low ground of the coastal plain south and east of Portsdown, the chalk is thickly covered by superficial deposits, and no good exposures were seen. It is likely that most of the mud-coated chalk appearing at low tide on the shore near Bosham and Chidham belongs to the Quadratus Zone. The locality last named is mentioned by Professor Barrois[2] as furnishing, or contributing to, a short list of fossils that includes "*Offaster corculum*, Gold." [= *O. pilula* (Lam.)] and "*Serpula plexus*, Sow."

Northern Outcrop.—In this case the sections to be described or mentioned will be taken approximately in their geographical order, from west to east. The majority of them are in the upper half of the zone, *i.e.*, the Subzone of *Actinocamax quadratus*.

On White Hill, at Upham, 15 feet of chalk with few flints is shown in a roadside pit a little below the contour of 300 feet. Fossils noted include—*Echinocorys scutatus* Leske (tall gibbous), *Serpula plexus* J. de C. Sow,. *Cribrilina gregoryi* Brydone, *Crania parisiensis* Defr., *Spondylus spinosus* (J. Sow.). Exposures of beds at about the same horizon are to be seen in the adjacent road-cutting on White Hill, and in other cuttings along the road south of Upham, between that village and Stake's Farm.

A large quarry one furlong north of Stake's Farm shows about 40 feet of beds in which courses of nodular flint are frequent, except in the lowest 8 feet, where there is one strongly-marked layer of the tabular variety. Gibbous and ovato-gibbous *Echinocorys*, *Offaster pilula* (Lam.) small, *Serpula turbinella* J. de C. Sow., and *Cribrilina gregoryi* Brydone are the most noteworthy fossils. Small free cheilostomous Bryozoa abound in the chalk occupying the external hollows of the flints.

A patch of fossiliferous chalk (*Bourgueticrinus*, *Kingena lima* (Defr.), &c.) was observed in a lane-bank west of Grasted Copse. Beds in the *Act. quadratus* Subzone are to be seen also in a dell near the south-eastern end of this copse; and a poor exposure of chalk in the Subzone of *Offaster pilula* is given in a pit on Stephen's Castle Down, a quarter of a mile west-south-west of Dean Farm.

Good sections in the *Act. quadratus* Subzone exist in several places at and north of Bishop's Waltham, *e.g.*, at the Gas Works a quarter of a mile north of the parish church; in Chalky Lane, the same distance north-east of that building; 3 furlongs south-west of Bishop's Down Farm; at the Water Works a quarter of a mile south of the House at Vernon Hill; and in workings near the 'White Horse' inn on the high road to Winchester. The chalk contains numerous flint-courses, which, in the larger sections, indicate low dips west of south. The fossils—generally similar in all cases—include *Porosphaera nuciformis* v. Hag., *Bourgueticrinus* (special forms), *Metopaster parkinsoni* (Forbes), *M. uncatus* (Forbes), *Stauranderaster ocellatus* (Forbes), *Echinocorys scutatus* Leske (gibbous), *Helicodiadema fragile* (Wilts.), *Offaster pilula* (Lam.) small, *Serpula ilium* Goldf., *S. turbinella* J. de C. Sow., *Rhynchonella limbata* (v. Schloth.), *Pecten quinquecostatus* J. Sow., *P. sarumensis* Woods, *Spondylus dutempleanus* d'Orb. The chalk in the upper part of the quarry at the Water Works is rich in Bryozoa (*Clausa francqana* d'Orb., *Membranipora langi* Brydone, &c.) and other small fossils.

Farther east many other exposures in the same part of the Quadratus Zone are to be seen in old pits about Swanmore, *e.g.*, south and north-east of Hoe; a furlong north-west of Hill Grove; north-west and south-west of Mayhill Farm (at places where dips are marked on the map); and south-west of Midlington House[3]; and there are degraded workings, which seem to be in the Subzone of *Offaster pilula*, south of Dundridge and 3 furlongs north-north-east of Swanmore House.

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[1] Griffith and Brydone, *op. cit.*, p. 21; Brydone, *op. cit.*, p. 9.

[2] Recherches sur le terrain Crétacé . . . de l'Angleterre &c.' 1876, p. 35.

[3] These and several more are noticed by R. M. Brydone, 'Stratigraphy of the Chalk of Hants,' 1912, pp. 100, 101.

Chalk in the upper part of the zone has been dug near the high road along the right bank of the River Meon north and south-west of St. Clair's Farm.

At Soberton the lower of two quarries, about a quarter of a mile south-east of the church, shows, at the foot of its northern face, 8 feet of the passage-beds between the Marsupites and Quadratus Zones, which Mr. Brydone refers to the *Echinocorys depressus* division of the latter Zone[1] (see pp. 23-25). Among the thinly scattered flints the grey, almond-shaped sort, often to be seen in the Marsupites Band in Hampshire, are fairly common. Oysters (*O. vesicularis* (Lam.), *O. wegmanniana* d'Orb.) abound, and in places are crowded together in lenticular bands containing much comminuted *Inoceramus*. Other fossils seen were—*Porosphaera pileolus* (Lam.), *Bourgueticrinus* (' form 6 ' Brydone), *Metopaster parkinsoni* (Forbes), *Cyphosoma koenigi* ? Mant. (radioles), *Echinocorys scutatus* var. *tectiformis* Brydone, *Micraster coranguinum* (Leske), *Rhynchonella plicatilis* (J. Sow.), *Spondylus dutempleanus* d'Orb. Mr. Brydone records *Gyropleura inequirostrata* S. Woodw. and *Leiodon sp.* from this section.

The upper quarry at Soberton—south of the last, and based in beds estimated to be about 25 feet higher than those just described—shows a good section in the lower part of the *Offaster pilula* Subzone. The chalk, of which about 25 feet is exposed, is distinctly bedded, seams and fine partings of grey marl occurring at intervals of 1 to 2 feet. Lenticular bands of ironstained subnodular chalk, with impressions of sponges, are conspicuous. The flints—thick rinded and often elongate—occur in definite courses, and dispersedly in indistinct bands. Stout fragments of *Inoceramus* (*I. inconstans* ? Woods) are plentiful; other noteworthy fossils are—*Bourgueticrinus* (' form 1 ' Griffith & Brydone), *Offaster pilula* (Lam.) (common), *Serpula ilium* Goldf., and large *Spondylus spinosus* (J. Sow.), found by the writer; and *Echinocorys scutatus* var. *truncatus* Griffith & Brydone, *Terebratulina rowei* Kitchin, *Actinocamax quadratus* Defr., and *Aptychus leptophyllus* Sharpe, recorded by Mr. Brydone.

There are degraded pits in the upper part of the Quadratus Zone, close to the boundary of the Reading Beds, south-west of Wehsgreen Farm, and at Inklefield (or Ingoldfield) Farm south-east of Soberton Heath. From the latter—mentioned by Professor Barrois[2]—Mr. Brydone obtained *Cidaris pleracantha* Agas. and dwarf *Offaster pilula* (Lam.).

In the neighbourhood of Hambledon some of the lower beds of the zone are exposed in a pit a quarter of a mile north of Scotland on Broadhalfpenny Down; and chalk with *Offaster pilula* in a run-down pit the same distance west-north-west of Glidden; while parts of the highest subzone are to be seen in dells north and east of the outlier of Reading Beds near Hole, and near the boundary of the Eocene main-mass north-west and south-west of Pithill Farm, and at Anmore.[3]

At the northern end of Lovedean a pit on the eastern side of the road to Clanfield shows upwards of 30 feet of the *Act. quadratus* Subzone with many dispersed, small, globular flints and larger thick-rinded nodules in courses which mark a low dip to the south. Weathered surfaces exhibit numerous small remains:—*Porosphaera nuciformis* v. Hag., *Bourgueticrinus* (' form 4 ' Griffith & Brydone), *Asteroidea* (*Metopaster uncatus* (Forbes), &c.), *Serpulae* (especially *S. turbinella* J. de C. Sow), together with *Rhynchonella limbata* (v. Schloth.), *Terebratulina striata* Dav., *Ostreae*, *Pecten quinquecostatus* J. Sow., *Corax pristodontus* Agassiz.

Passing over three exposures close to the Reading Beds near Causeway and Merchistoun Hall, it may be noted that chalk with abundant *Serpula turbinella*, and, in other respects similar to that seen in the Lovedean pit, appears in a dell about 300 yards south-east of the eastern church at Blendworth.

Eastward of Blendworth the outcrop belt of the Quadratus Zone widens, and takes in most of the ground between the Eocene boundary and a

[1] *Op. cit.*, p. 96.
[2] ' Recherches sur le terrain Crétacé, &c.' 1876, p. 37.
[3] See also Brydone, *op. cit.*, pp. 96, 98, 102.

straight line drawn from the northern end of Windmill Hill (near Chalton) to Up Marden. Of the many exposures which this area affords, a small proportion only can here be noticed.

Mr. Brydone[1] records dwarf *Offaster pilula* from a pit west of the railway about one-third of a mile north of Rowland's Castle Station, and *Cidaris pleracantha* Agas. from Calf Dell south-west of Deanlane End. It must suffice merely to mention the exposures at Warren Hill, north of Stansted Forest; the road cuttings south-west and east of West Marden; a pit 500 yards south-east of Compton church; and another working north-west of Broadreed Farm.

Chalk with *Offaster pilula* (Lam.) (large), and *Cribrilina gregoryi* Brydone appears in road-banks 5 furlongs south of Up Marden, and is well displayed in a quarry, 40 to 50 feet deep, south-east of Ashdean House, near Funtington. The flint-courses, dipping 3° to 4° rather west of south, occur more freely in the upper than in the lower half of the section.

A dip of 5° about west-south-west is indicated by the frequent bands and layers of nodular and tabular flint seen in a small pit on the contour of 200 feet one-fourth of a mile south-east of Walderton. Bryozoa (notably *Entalophora virgula* v. Hag.) are common here in the chalk adhering to the flints (as in the quarry near Stake's Farm, Upham, noticed above, p. 30), but other sorts of fossils are rather scarce. Those found comprise *Porosphaera globularis* (Phill.), *Bourgueticrinus* ('form 7' Brydone), *Helicodiadema fragile* (Wilts.), *Terebratula semiglobosa* J. Sow. (small), small *Ostreae*, *Pecten cretosus* Defr., *Aptychus leptophyllus* Sharpe. This chalk probably belongs to the Subzone of *Act. quadratus*.

As already intimated (p. 15), the mapping of an inlier of Middle Chalk around Stoughton is due to a misapprehension. The existing exposures are poor, but an inspection of these has left little room for doubt that the site of the supposed inlier is occupied by Upper Chalk. It is unlikely that beds older than the Marsupites Zone come to the surface hereabouts.

Small bared patches of soft to firm white chalk with thick-rinded nodular and tabular flints occur by the cart-tracks on Walderton Down south-east of the main road through Stoughton. North-east of the village, chalk and flints of similar character were thrown out of a temporary excavation at the spot marked "169" on the map. At this point the road from Stoughton turns eastward, and ascends the western slope of Lambdown Hill in a shallow cutting whose sides afford several little exposures of soft, fine-grained white chalk containing few scattered flints with thick rinds. The only noteworthy fossils seen (mostly near the higher end of the cutting) were—*Bourgueticrinus* ('form 6' Brydone), *Inoceramus inconstans* ? Woods, *Ostrea* cf. *alaeformis* S. Woodw., *O. vesicularis* (Lam.), *O. wegmanniana* d'Orb.; the last two being common in places. The lowest '*Echinocorys depressus*'—beds of the Quadratus Zone are indicated.

By the south side of the same road, at the point where it crosses the boundary of the district dealt with in this Memoir, there is a disused pit, about 18 feet deep, which formerly showed "hard nodular chalk with a line of grey flints at the top."[2] The face of the working is now covered by sheep-trodden talus, but in the lower part two bands of hard, iron-stained nodular chalk, about a foot thick and 5 feet apart, can be distinguished in small ledges or projections. A layer of light-green nodules, traversed by borings, occurs at the top of the lower band. Excepting rusty impressions of sponges, fossils are rare in the nodular bands; and most of the following were obtained from little openings made in soft chalk between and above them:—*Frondicularia sp.* (big), *Plinthosellae*, *Porosphaera globularis* (Phill.) (rather large), *P. patelliformis* Hinde, Asteroidea, *Echinocorys scutatus* Leske (fragments common; apparently of two forms; one large, with thick base, the other suggestive of the var. *cinctus* Brydone), *Cribrilina gregoryi* Brydone (rather common), *Crania egnabergensis* Retz., *Ostrea lateralis* Nilss (striate), *Pecten* (*Neithea*) *quinquecostatus* J. Sow., *Spondylus latus* (J. Sow.). Despite the absence or rarity of *Offaster pilula*, this chalk may be referred to the Subzone of that echinoid.

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[1] *Op. cit.*, p. 102.

[2] C. Reid, 'Country near Chichester' (*Mem. Geol. Survey*) 1903, p. 27.

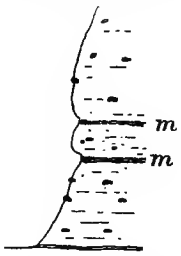
Zone of Belemnitella mucronata.

As far as is known, the local exposures are confined to the Portsdown area. The researches of Messrs. Griffith and Brydone have shown that the outcrop of this zone extends from the neighbourhood of Fontley to that of Downend House near Fareham, on the south, and is connected, by way of the Wallington Valley, with the outcrop seen at Offwell Farm and Bedhampton, on the north.

As stated above, the basal beds are exposed in the road-cutting north of the Lime Works at Bedhampton (*see* footnote, p. 28). The two marl-seams are there just one foot apart (fig. 6). The lower seam, which here and elsewhere is the more strongly marked, gives indications of current action in its varying texture, streaky laminae, and small inclusions of

FIG. 6.—*Marl-seams in the Chalk, Bedhampton.*

Scale: 1 inch = 6 feet.



m m. Marl-seams.

white chalk. It contains much broken *Inoceramus*, along with small *Porosphaerae*, Asteroid ossicles, &c. Between the marls there is an impersistent ironstained band, 2 to 3 inches thick, with impressions of siliceous sponges. The few feet of overlying chalk is not well placed for examination. Mr. Brydone states[1] that *Belemnitella mucronata* v. Schloth. has been found in this section; and he records its occurrence at the top of the adjacent quarry (in the Quadratus Zone) at the Lime Works.[2]

The lowest beds of the Zone are seen again on the northern side of the trench at Farlington redoubt, a mile west of Bedhampton. The occurrence of the zonal name-fossil here is recorded by Professor Barrois,[3] who mentions among other associated fossils *Cardiaster héberti* Cott., and two forms of *Echinocorys*. Here, also, *Belemnitella mucronata* has been found below the basal marl-seams.

These two seams are distinguishable near the northern end of the quarry south of Offwell Farm, but the low face of chalk there is much weather-stained. Mr. Brydone has the characteristic small, subconical *Echinocorys scutatus* Leske from the Mucronata Beds here, and the writer an undescribed form of *Bourgueticrinus, Stauranderaster senoniensis* (Valette), &c.

The junction with the Quadratus Zone is shown in the pit (now used as a cattle-pen) at White Dell Farm, and in the more accessible section at the Water Works north-east of Wallington. The latter exposes about 10 feet of the Quadratus, and about 25 feet of the Mucronata, Beds. The marly seams at the junction are here 1½ feet apart; and the lower seam in places is crammed with bits of *Inoceramus*, which stand out in sheaves on

[1] *In lit.*

[2] 'Stratigraphy of the Chalk of Hants,' 1912, p.

[3] *Op. cit.* p. 35.

weathered surfaces. In the overlying chalk Brachiopods are abundant, the commonest forms being—*Rhynchonella limbata* (v. Schloth.), *R. plicatilis* (J. Sow.), and *Terebratula carnea* J. Sow.; and the associated forms including *Kingena lima* (Defr.), *Terebratula semiglobosa* J. Sow. (small), and *Thecidium wetherelli* Morris. Apart from *Belemnitella mucronata* v. Schloth. and *Echinocorys scutatus* Leske, which seem not to be common, the other fossils observed by the writer were not zonally distinctive.

Messrs. Griffith and Brydone have identified Mucronata Chalk in the eastern face of the Clapperhill pit, 300 yards north of the Water Works.

In the western part of the quarry at the Whiting Works nearly half a mile north-east of Downend House, the lower beds of the zone are well displayed for a thickness of about 40 feet above the Quadratus Chalk. The lower of the basal marl-seams, with its inclusions of white chalk and broken *Inoceramus*, is as clearly marked as usual, but the upper is faint and feathery where it can be discerned at all. In the chalk above, flints occur in open courses, and mostly possess banded rinds. Compound nodules, upwards of a foot in diameter, are not uncommon. The fossils observed by the writer included *Porosphaerae*, *Asteroidea*, *Echinocorys scutatus* var. *subconicus* Griffith & Brydone, most of the brachiopod forms noted at the Water Works, *Ostrea vesicularis* (Lam.) (stout), and *Belemnitella mucronata* v. Schloth. A set of fossils collected by the quarry-men included several examples of the last-named and of *Echinocorys scutatus* Leske of various shapes; also fish-teeth, referable to *Lamna* and *Corax*, from divers parts of the quarry. An example of *Belemnitella lanceolata* v. Schloth. has been found in the Mucronata Beds of this section.[1]

North-east of Downend House a disused quarry near the railway shows about 50 feet of beds, some of which may be higher in the zone than any exposed at the Whiting Works, a quarter of a mile distant. Thin, greyish, marly seams are common, and occur in groups. The flints are mostly scattered, only one course of them being at all conspicuous. Several examples were noted of elongate and fusiform nodules disposed at right angles to the bedding—incipient paramoudras. *Belemnitella mucronata* has been found,[2] but this and other distinctive fossils seem scarce. The writer observed *Echinocorys scutatus* Leske (stout, sub-pyramidate), a few Bryozoa and Brachiopoda, *Inoceramus inconstans* Woods, and *Ostreae*.

From a pit at Dean Farm, near Knillers Court, Mr. Brydone records *Belemnitella mucronata*, *Echinocorys scutatus* var. *subconicus* Griffith & Brydone, and *Gyropleura inequirostrata* S. Woodward.

List of Fossils.

In the following list of Chalk fossils from the area of the Fareham Sheet (No. 316) of the One-inch Ordnance Survey Map, the species marked with a cross (×) in the vertical columns on the right are those found by the writer of the present Memoir, who is indebted to Messrs. Ll. Treacher, W. D. Lang, and T. H. Withers for some determinations and comparisons. Species recorded on the authority of others are marked by the letters Br, G, R, and S, which denote—

Br. Mr. R. M. Brydone, "Notes on new or imperfectly known Polyzoa," *Geol. Mag.*, 1912, pp. 296, 435; "Stratigraphy of the Chalk of Hants," 1912 (*London: Dulau and Co., Ltd.*).

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[1] Griffith & Brydone, *op. cit.*, p. 21.

[2] By R. M. Brydone. He states (*in. lit.*, Jan. 30, 1913) that some years ago he saw doubtful indications of Quadratus Chalk at the foot of the overgrown northern wall of this quarry, below a marl-seam 38 feet from the top of that side of the working; but that "only neutral fossils were found" there.

G. Messrs. C. Griffith and R. M. Brydone, in Mr. A. J. Jukes-Browne's "Cretaceous Rocks of Britain" (*Mem. Geol. Survey*), vol. iii, 1904, pp. 64-68; in their "Zones of the Chalk in Hants," 1912 (*London: Dulau and Co., Ltd.*), and in Mr. C. Griffith's "Geological Notes," *Winchester Coll. Nat. Hist. Soc.*, 1912 (*Winchester: P. and G. Wells*).

R. Dr. A. W. Rowe, "Zones of the White Chalk of the English Coast, pt. V." *Proc. Geol. Assoc.*, vol. xx, 1908, pp. 311, 312; and MS. lists of fossils collected at Portsdown in 1908.

S. Geological Survey Collection, from a list in Mr. A. J. Jukes-Browne's "Cretaceous Rocks of Britain" (*Mem. Geol. Survey*), vol. ii, 1903, pp. 66, 67.

List of Chalk Fossils.	Lower Chalk Zones.		Middle Chalk Zones.		Upper Chalk Zones.					
	Schloenb. varians.	Hol. subglobosus.	Rhynch. cuvieri.	Terebratulina lata.	Holaster planus.	M. cortestudinarium.	M. coranguinum.	Marsupites.	Act. quadratus.	Bel. mucronata.
RHIZOPODA.										
Cristellaria rotulata *Lam.*	×	—	—	—	—	—	—	—	×	
Frondicularia sp.	—	—	—	—	—	—	—	—	×	
Webbina sp.	—	—	—	—	—	—	—	—	×	
SPONGIAE.										
Camerospongia capitata *T. Smith* ...	—	×								
—— subrotunda (*Mant.*)	—	—	—	—	—	—	—	—	Br	
Cliona cretacea *Portl.*	—	—	—	—	—	—	—	—	—	×
Coscinopora quincuncialis (*T. Smith*)	—	—	×	—	—	—	—	×	×	
Heterostinia obliqua *Benett*	—	—	—	—	—	—	—	—	G	
Pharetrospongia strahani *Sollas* ...	—	—	—	—	—	—	×	—	×	
Plinthosella squamosa *Zitt.*	—	—	—	—	—	—	—	—	×	
Plocoscyphia convoluta (*T. Smith*) ...	—	—	×	—	—	—	—	—	×	
—— maeandrina *Goldf.*	×									
Porosphaera arrecta *Hinde*	—	—	—	—	—	—	—	—	—	G
—— globularis (*Phill.*)	—	—	—	—	—	—	×	×	×	×
—— nuciformis *v. Hag.*	—	—	—	—	—	—	—	G	×	×
—— patelliformis *Hinde*	—	—	—	—	—	—	—	—	×	G
—— pileolus (*Lam.*)	—	—	—	—	—	—	—	×	×	G
—— pustulosa *Brydone*	—	—	—	—	—	—	—	—	Br	
—— taeniiformis *Brydone*	—	—	—	—	—	—	—	—	Br	
Talpina sp.	—	—	—	—	—	—	—	—	G	
Ventriculites mammillaris *T. Smith* ...	—	—	—	—	×					
—— radiatus *Mant.*	—	—	—	—	—	—	—	—	×	
ANTHOZOA.										
Axogaster cretacea *Lonsd.*	—	—	—	—	×	—	—	—	G	G
Diblasus grevensis *Lonsd.*	—	—	—	—	—	—	—	—	×	

List of Chalk Fossils (*continued*).	Lower Chalk Zones.		Middle Chalk Zones.		Upper Chalk Zones.					
	Schloenb. varians.	Hol. subglobosus.	Rhynch. cuvieri.	Terebratulina lata.	Holaster planus.	M. cortestudinarium.	M. coranguinum.	Marsupites.	Act. quadratus.	Bel. mucronata.
Epiphaxum auloporides *Lonsd.* ...	—	—	—	—	—	—	—	—	—	Br
Parasmilia centralis (*Mant.*)... ...	—	—	—	—	×	—	—	—	G	
—— *cf.* mantelli *Edw. & Haime* ...	—	—	—	—	—	—	—	—	×	
Onchotrochus serpentinus *Dunc.* ...	G									
Coelosmilia laxa *Edw. & Haime* ...	—	—	—	—	—	—	—	—	R	
Stephanophyllia bowerbanki *Edw. & Haime*	×									
Micrabacia coronula (*Goldf.*) ...	G									
HYDROZOA.										
Retispinopora arbusculum *Brydone*...	—	—	—	—	—	—	—	—	—	Br
Spinopora dixoni *Lonsd.*	—	—	—	—	—	—	—	—	×	
ECHINODERMATA.										
Crinoidea.										
Bourgueticrinus ellipticus (*Miller*)...	—	—	Br	×	×	—	×	×	×	×
Marsupites testudinarius (*v. Schloth.*)	—	—	—	—	—	—	—	×		
Pentacrinus	—	—	Br	—	—	—	—	—	Br	
Uintacrinus sp.	—	—	—	—	—	—	—	×		
Asteroidea.										
Calliderma latum *Forbes*	—	—	—	—	—	—	—	G		
Metopaster parkinsoni (*Forbes*) ...	—	—	—	—	—	—	—	×	×	×
—— uncatus (*Forbes*)	—	—	—	—	—	—	—	—	×	
Nympbaster rugosus *Sladen*	—	—	—	—	—	—	—	—	×	
Pentagonaster quinquelobus (*Goldf.*)	—	—	—	—	—	—	—	×	×	×
Pycinaster angustatus (*Forbes*) ...	—	—	—	—	—	—	—	—	×	G
Stauranderaster bulbiferus (*Forbes*)	—	—	—	—	—	—	—	—	×	
—— ocellatus (*Forbes*)	—	—	—	—	—	—	×	—	×	G
—— senoniensis (*Valette*)	—	—	—	—	—	—	—	—	×	×
Echinoidea.										
Cidaris hirudo *Sorig.*...	—	—	×	—	—	—	—	G	R	G
—— perornata *Forbes*	—	—	—	—	—	—	×	—	Br	G
—— pleracantha *Agas.*	—	—	—	—	—	—	—	—	×	G
—— sceptrifera? *Mant.*	—	—	—	—	—	—	—	—	—	G
—— serrifera *Forbes*	—	—	—	—	—	—	—	—	×	
—— subvesiculosa *d'Orb.*	—	—	—	—	—	—	—	×	×	
Cyphosoma koenigi? *Mant.*	—	—	—	—	—	—	—	×		
—— radiatum *Sorig.*...	—	—	—	×						
—— spatuliferum *Forbes*	—	—	—	—	—	—	—	—	R	
Helicodiadema fragile (*Wilts.*) ...	—	—	—	—	—	—	—	—	×	G
Salenia geometrica *Agas.*	—	—	—	—	—	—	—	—	R	G
—— granulosa *Forbes*	—	—	—	—	—	—	—	—	G	Br
Cardiaster héberti *Cott.*	—	—	—	—	—	—	—	—	Br	G
Conulus albogalerus *Leske*	—	—	—	—	—	—	×			

List of Chalk Fossils (*continued*).	Lower Chalk Zones.		Middle Chalk Zones.		Upper Chalk Zones.					
	Schloenb. varians.	Hol. subglobosus.	Rhynch. cuvieri.	Terebratulina lata.	Holaster planus.	M. cortestudinarium.	M. coranguinum.	Marsupites.	Act. quadratus.	Bel. mucronata.
Conulus globulus *Desor*	—	—	—	—	—	—	—	G		
—— subrotundus *Mant.*	—	—	—	Br						
Discoidea cylindrica (*Lam.*)	×									
—— dixoni *Forbes*	—	—	Br	×						
Echinocorys scutatus *Leske* ...	—	—	—	—	×	×	×	×	×	×
Hemiaster minimus *Agas.*	—	—	Br							
Holaster placenta *Agas.*	—	—	—	—	—	Br				
—— planus *Mant.*	—	—	—	—	×					
—— subglobosus *Leske*	G									
Micraster coranguinum (*Leske*) ...	—	—	—	—	—	—	×	×	R	G
—— corbovis *Forbes*...	—	—	—	Br						
—— cortestudinarium (*Goldf.*) ...	—	—	—	—	—	×	×			
—— leskei *Desm.*	—	—	—	—	Br					
—— praecursor *Rowe*	—	—	—	—	×					
Offaster pilula (*Lam.*)	—	—	—	—	—	—	—	—	×	G
ANNELIDA.										
Serpula ampullacea *J. de C. Sow.* ...	×	—	—	—	—	—	—	G	×	G
—— cincta *Goldf.*	—	—	—	—	—	×				
—— difformis *Lam.*	—	—	—	—	—	—	—	—		G
—— fluctuata *J. de C. Sow.*... ...	—	—	—	—	—	—	—	—	G	G
—— gordialis *v. Schloth.*	—	—	—	—	—	—	—	—	—	G
—— granulata *J. de C. Sow.* ...	—	—	—	—	—	—	—	—	×	G
—— ilium *Goldf.*	—	—	—	—	—	—	—	—	×	
—— plexus *J. de C. Sow.*	—	—	—	—	—	—	—	G	×	G
—— turbinella *J. de C. Sow.* ...	—	—	—	—	—	—	—	—	×	G
—— umbonata *J. de C. Sow.* ...	S									
Terebella ? lewesiensis *Mant.* ...	—	—	—	×	—	—	—	—	×	
BRYOZOA.										
Cyclostomata.										
Berenicea cf. gracilis (*M. Edw.*) ...	—	—	—	—	—	—	—	—	—	×
Clausa francqana *d'Orb*	—	—	—	—	—	—	—	—	×	
—— globulosa *d'Orb.*	—	—	—	—	—	—	—	—	×	
—— heteropora *d'Orb.*	—	—	—	—	—	—	—	—	×	
Entalophora echinata (*v. Reuss*) ...	—	—	—	—	—	—	—	—	×	
—— virgula (*v. Hag.*)	—	—	—	—	—	—	—	—	×	
Homoeosolen ramulosus *Lonsd.* ...	—	—	—	—	—	—	—	—	×	
Lunulites cretaceus *Defr.*	—	—	—	—	—	—	—	—	R	G
Meliceritites dolfussi *Perg.*	—	—	—	—	—	—	—	—	R	
Proboscina cornucopiae *d'Orb.* ...	—	—	—	—	—	—	—	—	×	
—— radiolitorum *d'Orb.*	—	—	—	—	—	—	×			
Reptomultisparsa congesta *v. Reuss*....	—	—	—	—	×					
—— rowei *Greg.*	—	—	—	—	—	—	—	—	—	×
Sparsicavea carantina *d'Orb*	—	—	—	—	—	—	—	—	R	
Spiropora verticillata *Goldf.*... ...	—	—	—	—	—	—	—	—	R	
Stomatopora granulata (*M. Edw.*) ...	—	—	—	—	—	—	—	—	×	
—— gracilis (*M. Edw.*)	—	—	—	—	—	—	—	—	×	

List of Chalk Fossils (*continued*).	Lower Chalk Zones.		Middle Chalk Zones.		Upper Chalk Zones.					
	Schloenb. varians.	Hol. subglobosus.	Rhynch. cuvieri.	Terebratulina lata.	Holaster planus.	M. cortestudinarium.	M. coranguinum.	Marsupites.	Act. quadratus.	Bel. mucronata.
Cheilostomata.										
Cribrilina gregoryi *Brydone*	—	—	—	—	—	—	Br	—	×	
—— lineata *Vine*	—	—	—	—	—	—	×			
Eschara acis *d'Orb.*	—	—	—	—	—	—	—	—	×	
—— galeata *v. Hag.*	—	—	—	—	—	—	—	—	R	
—— rimosa *Marss.*	—	—	—	—	—	—	—	—	R	
Membranipora langi *Brydone* ...	—	—	—	—	—	—	—	—	×	
—— pellicula *Brydone*	—	—	—	—	—	—	—	—	Br	
—— pyrigera *Brydone*	—	—	—	—	—	—	—	—	Br	
Onychocella lamarcki (*v. Hag.*) ...	—	—	—	—	—	—	—	—	×	
Semieschara pergensi *Brydone* ...	—	—	—	—	—	—	—	—	—	Br
—— woodsi *Brydone*...	—	—	—	—	—	—	—	—	—	Br
Vincularia disparilis *d'Orb*	—	—	—	—	—	—	—	—	R	
—— santonensis *d'Orb.*	—	—	—	—	—	—	—	—	R	
BRACHIOPODA.										
Cistella bronni *v. Hag.*	—	—	—	—	—	—	—	—	—	G
Crania costata? *J. Sow.*	—	—	—	—	—	—	—	—	Br	
—— egnabergensis *Retz.*	—	—	—	—	—	—	—	—	×	×
—— parisiensis *Defr.*	—	—	—	—	—	—	—	—	×	G
—— striata ? *Retz.*	—	—	—	—	—	—	—	—	—	G
Kingena lima (*Defr.*)	×	—	—	—	—	—	—	—	×	×
Lingula subovalis *Dav.*	G									
Rhynchonella cuvieri *d'Orb.* ...	—	—	×							
—— dimidiata, *J. Sow.*	S									
—— grasiana *d'Orb.*	G									
—— limbata (*v. Schloth.*)	—	—	—	—	—	—	—	—	×	×
—— mantelliana *J. de C. Sow.* ...	—	—	—	—	—	—	—	—	—	G
—— martini *Mant.*	×									
—— plicatilis (*J. Sow.*)	—	—	—	×	×	—	—	×	×	×
—— reedensis *Eth.*	—	—	—	—	×	—	—	G	×	G
Terebratula carnea *J. Sow.*	—	—	—	—	×	—	—	—	×	×
—— obesa *J. Sow.*	—	—	—	—	—	—	—	—	—	G
—— semiglobosa *J. Sow.*	×	—	×	×	—	—	—	—	×	×
Terebratulina lata *Eth.*	—	—	—	×						
—— rowei *Kitch.*	—	—	—	—	—	—	—	—	R	
—— striata *Dav.*	×	—	—	—	—	—	—	G	×	G
Thecidium brydonei *Kitch.*	—	—	—	—	—	—	—	—	—	G
—— wetherelli *Morris*	—	—	—	—	×	—	—	—	—	×
LAMELLIBRANCHIATA.										
Alectryonia ungulata *v. Schloth.* ...	—	—	—	—	—	—	—	—	G	
Anomia papyracea *d'Orb.*	—	—	Br	Br						
Arca sp.	G									
Avicula caerulescens *Goldf.*	—	—	—	—	—	—	—	—	Br	
Dimyodon nilssonii (*v. Hag.*) ...	—	—	—	—	×	—	—	G	×	×

List of Chalk Fossils (*continued*).	Lower Chalk Zones.		Middle Chalk Zones.		Upper Chalk Zones.					
	Schloenb. varians.	Hol. subglobosus.	Rhynch. cuvieri.	Terebratulina lata.	Holaster planus.	M. cortestudinarium.	M. coranguinum.	Marsupites.	Act. quadratus.	Bel. mucronata.
Gyropleura inequirostrata *S. Woodw.*	—	—	—	—	—	—	—	—	Br	G
Inoceramus brongniarti (*see* lamarcki).										
—— balticus *Böhm.*	—	—	—	—	—	—	—	—	Br	Br
—— crippsi *Mant.*	×									
—— —— var. reachensis *Eth.* ...	×									
—— inconstans *Woods*	—	—	—	—	—	—	—	—	×	×
—— labiatus *v. Schloth.*	—	—	×							
—— —— *var.* latus *J. de C. Sow.* ...	—	—	—	×	×					
—— lamarcki *Park.*	—	—	—	×						
—— —— *var.* cuvieri *J. de C. Sow.*	—	—	—	—	—	—	×			
—— mytiloides (*see* labiatus).										
Lima cretacea *Woods*	—	—	—	Br						
—— granulata *Nilss.*	—	—	—	—	—	—	—	Br	R	G
—— (Ctenoides) divaricata *Dujar.*	—	—	—	—	—	—	—	—	—	G
—— (Limatula) decussata *Goldf.* ...	—	—	—	×						
—— —— wintonensis *Woods* ...	—	—	—	—	—	—	—	—	—	G
—— (Plagiostoma) globosa (*J. de C. Sow.*)	G									
—— —— hoperi *Mant.*	—	—	—	×	×	—	—	G	Br	
Ostrea acutirostris *Nilss.*	—	—	—	—	—	—	—	—	G	
—— cf. alaeformis *S. Woodw.* ...	—	—	—	—	—	—	—	—	×	
—— curvirostris *Nilss.*	—	—	—	—	—	—	—	G		
—— hippopodium *Nilss.*	—	×	—	—	—	—	—	G	×	G
—— lateralis *Nilss.* [canaliculata *J. Sow.*]	—	—	—	—	—	—	—	G	×	G
—— —— —— (*striate var.*) ...	—	—	—	—	—	—	—	—	×	G
—— normaniana *d'Orb.*	—	—	—	—	—	—	×			
—— semiplana *Mant.*	—	—	—	×	—	—	—	—	G	
—— vesicularis (*Lam.*)	×	×	×	×	×	×	×	×	×	×
—— wegmanniana *d'Orb.*	—	—	—	—	—	—	—	G	×	G
Pecten (Aequipecten) beaveri *J. Sow.*	×									
—— —— pexatus *Woods*	—	—	—	—	—	—	—	—	G	G
—— —— sarumensis *Woods* ...	—	—	—	—	—	—	—	—	Br	
—— (Chlamys) cretosus *Defr.* ...	—	—	—	—	—	—	×	—	×	G
—— (Neithea) quinquecostatus *J. Sow.*	G	Br	—	—	—	—	—	—	×	G
—— (Syncyclonema) orbicularis *J. Sow.*	×									
Pinna decussata *Goldf.*	—	—	—	—	—	—	—	—	—	G
Plicatula barroisi *Peron*	—	—	—	—	×	—	—	—	×	G
—— gurgitis *Pict. and Roux* ...	×									
—— bantonensis *Brydone*	—	—	—	—	—	—	—	Br	Br	Br
Septifer lineatus (*J. de C. Sow.*) ...	—	—	—	—	—	—	—	G	G	Br
Pholadomya decussata *Phil.*	G									
Spondylus dutempleanus *d'Orb.* ...	—	—	—	—	—	—	—	×	×	G
—— latus (*J. Sow.*)	—	—	—	×	×	—	×	—	×	G
—— spinosus (*J. Sow.*)	—	—	—	×	×	—	—	G	×	G

List of Chalk Fossils (*continued*).	Lower Chalk Zones.		Middle Chalk Zones.		Upper Chalk Zones.					
	Schloenb. varians.	Hol. subglobosus.	Rhynch. cuvieri.	Terebratulina lata.	Holaster planus.	M. cortestudinarium.	M. coranguinum.	Marsupites.	Act. quadratus.	Bel. mucronata.
GASTEROPODA.										
Hipponyx dixoni *Desh.*	—	—	—	—	—	—	—	—	—	G
Natica sp.	G									
Pleurotomaria (Leptomaria) perspectiva (*Mant.*)	×									
CEPHALOPODA.										
Nautilus elegans? *J. Sow.*	S									
Actinocamax granulatus (*de Blainv.*)	—	—	—	—	—	—	—	G		
—— plenus (*Miller*)	—	Br								
—— quadratus (*Defr.*)	—	—	—	—	—	—	—	—	G	
Belemnitella lanceolata *v. Schloth.* ...	—	—	—	—	—	—	—	—	—	G
—— mucronata *v. Schloth.*	—	—	—	—	—	—	—	—	G	×
Belemnites ultimus *d'Orb.*	×									
Aptychus leptophyllus *Sharpe* ...	—	—	—	—	—	—	—	—	×	
—— rugosus *Sharpe*	—	—	—	—	—	—	—	—	—	G
—— sp.	—	—	—	—	—	—	—	—	—	G
Baculites baculoides *d'Orb.*	S									
Calycoceras naviculare (*Mant.*) ...	×									
Mantelliceras mantelli (*J. Sow.*) ...	×									
Metacanthoplites rotomagensis (*Brong.*)	×									
Scaphites aequalis *J. Sow.*	×									
—— cf. geinitzi *d'Orb.*	—	—	—	×						
Schloenbachia varians (*J. Sow.*) ...	×									
—— sp.	×									
Turrilites costatus *Lam.*	S									
—— scheuchzerianus *Bosc*	×									
CRUSTACEA.										
Pollicipes glaber *Roem.*	—	—	—	×	×	—	—	—	×	
—— filosus *Withers*	—	—	—	—	—	—	—	—	—	G
Scalpellum maximum *J. de C. Sow.*...	—	—	—	—	—	—	—	—	×	Br
PISCES.										
Corax falcatus *Agas.*	—	—	—	—	—	—	—	—	—	G
—— pristodontus *Agas.*	—	—	—	—	—	—	—	—	×	G
Cimolichthys lewesiensis *Leidy* ...	—	—	—	—	—	—	—	—	—	G
Lamna appendiculata *Agas.*	—	—	—	—	—	—	—	G	—	G
Oxyrhina mantelli *Agas.*	—	—	—	—	—	—	—	—	—	G
Macropoma sp. (*coprolites*)	×									
Protosphyraena ferox *Leidy*	—	—	—	—	—	—	—	—	—	G
Scapanorhynchus raphiodon *Agas.* ...	—	—	—	—	—	—	—	—	—	G
REPTILIA.										
Leidon sp.	—	—	—	—	—	—	—	—	Br	

CHAPTER VIII.

READING BEDS.

Although the junction of the Cretaceous with the Eocene Beds is nowhere clearly shown, their unconformability may be inferred from the observed relations of their outcrops in different parts of the district. Thus, the Mucronata Beds of the Chalk, which are exposed in several quarries in Portsdown, and are estimated to be about 60 or 70 feet thick near Fareham, have nowhere been observed, and in many places certainly are missing, along the northern boundary of the Eocene strata between Upham and Funtington. The local discordance here indicated is part of a widespread unconformity which in the South of England takes the form of an overstep of the Cretaceous by the Eocene in a northward direction, and involves the gradual cutting out of considerably more than half of the Upper Chalk in the interval of 50 miles between the Isle of Wight and the Berkshire Downs.

In other parts of the country the lowest of the Eocene sediments were deposited, as a rule, on an evenly-planed surface, and there is no reason to doubt that this was the case in the present district, where the Eocene beds immediately overlying the Chalk belong to the Reading Series. Here, as elsewhere, a thin layer of green-stained flints occurs at the junction, and is succeeded by a small thickness of sandy loam; but the seams of glauconitic sand, which characterise the 'Reading Bottom-bed' in so many other areas, are but feebly developed; while the commonly associated oyster-shells and fish-teeth seem to be wanting.

The bulk of the formation consists of clays and loams—grey, brown, red, and frequently mottled—in beds of lenticular form. Current-bedded sands occur here and there, in various positions with reference to the stratigraphic limits of the formation, but they are of little importance; and pebbly episodes, so common in the country to the west, are rarely encountered, either at the surface or in borings for water. Lignite has been found in a well at Havant, but leaf-beds seem to be unknown.

The average thickness may be set down as about 110 feet: the minimum so far recorded being 102 feet, in a well at Wickham: the maximum 125 feet, in a well at Hermitage, near Emsworth (*see* p. 90). In the latter case, however, some deduction probably ought to be made on account of the exaggerating effect of dip.

The general character of the Reading Series in the Fareham district is similar to that in the Isle of Wight, and indicates calmer conditions of deposition than prevailed in more northern and western areas of that problematical expanse of shallow water, the 'Woolwich and Reading lagoon.'

Notes of Exposures.

Northern Outcrop.—Beginning on the west, there are indications of sand, mostly in the lower beds, in several places between

Lower Upham and Bishop's Waltham. A well at Roke Farm, south-west of Vernon Hill, is said to be 19 feet deep in this sort of sediment; and ferruginous sand, with some ironstone, has been dug in the small plantation 300 yards east of the farm house.

In a boring put down through London Clay at Wintershill House, about 44 feet of mixed clay, earth, and chalk was encountered below some 75 feet of Reading Clays. Mr. W. Whitaker remarks, "The lower part of the section is very difficult to understand, there being no likeness to any of the older Tertiary beds, and the mixture with chalk being unique."[1] It may be that the lower part of the boring follows a 'pipe' in the Chalk.

At Bishop's Waltham a good exposure of coloured clays in the upper half of the formation is given in the pit at Messrs. Blanchard and Co.'s brickworks, in the western part of the town. The descending succession is:—

		Feet
London Clay.	Brown clay with septaria ... ... Brown loam with green grains and a few large flint-pebbles (obscured by slips)	about 30.
Reading Beds.	Mottled grey clay ... ... Dark grey clay, nearly black (8 feet) ... Red and grey mottled clay ... ... Grey-brown clay, stained red at top ...	about 50.

The bedding dips 5° south. Chalk is said to have been reached, in a well, at a depth of about 60 feet below the floor of the pit.

Yellow loamy sand comes in just below the London Clay south-west of the railway station, and is more clearly seen in the road-cutting by the (Coppice Hill) brickyard a quarter of a mile south of the parish church.

About Swanmore the Reading Beds are almost entirely mottled clays and loams. At the brickyard a quarter of a mile south-west of the church pits show about 12 feet of red-mottled silty clay, with small nodules of race in which the calcareous matter is imperfectly segregated.

At the south-eastern end of Swanmore, near the cross-roads by Hill Grove, and again at the north-western end of Soberton Heath, ditches show mottled clay within a foot or two of the top of the Chalk, and little or no sign of the green Bottom-bed, though in a well at the Gosport Waterworks, near Mislingford, 3 feet of "green sand and pebbles" was proved at this horizon.[2]

Brown and grey current-bedded sand, in the lower part of the formation, is dug in the gravel pit at World's End.

At Soak some pits on the eastern side of the road to Anmore show 6 to 8 feet of brown and red sands with seams of clay. These are near the top of the Series, and from Soak eastward, to Havant Thicket, sandy beds occur with some persistence in this position. Exposures can be seen in a pit south of Latchmore, and in small openings in the southern part of Blendworth Common, where sand appears to alternate with mottled clay. The outliers near Hamble-

[1] 'Water Supply of Hampshire' (*Mem. Geol. Surv.*), 1910, p. 141.
[2] *Ibid.* p. 126.

don and Lovedean are of the same prevailing argillaceous character as the lower beds in the main mass to the south of them.

The railway-cutting south of Rowland's Castle shows mottled red clay in the lower part of the series. In the brickyard just west of the railway here the clay is seen to be overlain by 4 to 8 feet of yellow sand, which is succeeded by more mottled clay.

Sand has been dug at the north-west corner of Emsworth Common, but eastward of this, at Westbourne Common, Woodmancote, and near Hambrook House, the visible parts of the Reading Beds are mostly clayey.

Southern Outcrop.—As this is barely separated from the northern outcrop at the eastern boundary of the district, it will be convenient to begin there and work westward.

Mottled clay is indicated beneath the superficial deposits at the head of Bosham Channel, and has been dug for bricks at Emsworth, in shallow pits a quarter of a mile south-south-west of the church. At New Brighton, north of Emsworth, a well-boring proved 109½ feet of coloured clays (with some sand) between the Chalk and the London Clay.[1] In a recent boring at Hermitage, particulars of which are given on a later page (90) of the present memoir, 111 feet of mottled clay, underlain by 14 feet of "sand clay, and gravel," is said to have been passed through between those horizons.

In a well close to the railway station at Havant, the Reading Beds—"109 feet or more" thick—were found to be composed mainly of sandy clays with lignite in the upper half, and of stiff variegated clay in the lower half.[2]

Along the northern side of Portsdown the Reading Beds outcrop in a narrow strip of ground (mostly under grass) in which there are no good exposures. Both there and in the expansion of the outcrop around Whiteley, south of Curbridge, the prevalence of clay and loam is indicated.

A well-boring at Wickham[3] gave the following complete section of the formation:—

		Feet.
(London Clay)	Blue lias and marl	8
	Marl	28
(Reading Beds, 102 feet).	Mottled clay	10
	Brown marl...	17½
	Dead green sand	6½
	Live sand	10
	Mottled clay	33½
	Mottled clay and marl ...	8½
	Mottled clay	12½
	Green sand	1½
(Upper Chalk)	Hard marl	2½
	Marl-rock	1½
	Chalk and flints	38 "

The beds in the Reading Series here described as "marl" may be loams containing race, or merely silty loams or clays; and the

[1] 'Water Supply of Hampshire' (*Mem. Geol. Surv.*), 1910, p. 79.
[2] *Op. cit.* p. 95. [3] *Op. cit.* p. 143.

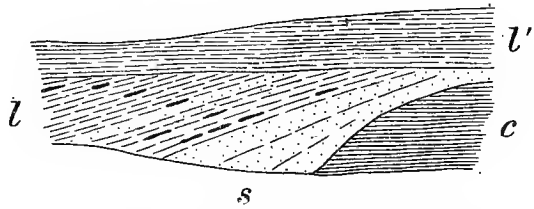
words "hard marl" and "marl-rock," farther down, may be taken to mean that the Chalk was found to be dirty and indurated (as it often is) near the junction. Pieces of stained and toughened chalk were noted at the boundary of the small outlier of mottled clay south of the County Lunatic Asylum.

Several sections are presented in the brick-and-tile yards between Fontley and Fareham. Coloured clays appear in most of the workings, and at Fontley there is little of any other sort of sediment in the formation, sand required for brick-making having to be fetched from pits in the Bagshot Beds at the top of the bluff to the south; but towards Fareham the upper beds become largely arenaceous.

Mr. J. Sandy's brick-pits, west of Fareham Workhouse, show obliquely-bedded brown and yellow sands and sandy loams, with seams and rolled pieces of clay, banked against and overlapping

FIG. 7.—*Section in the Reading Beds, Fareham.*

Scale : roughly 1 inch = 20 feet.



c. Mottled clay, *s*. Loamy sand, *l*. Loam, *l'*. Loam (? partly London Clay).

a mass of mottled clay; the whole being covered by light-brown loam (obscured), near the junction with the London Clay (Fig. 7). Near this section, and at a lower level, light-yellow sand was exposed in a temporary excavation in the roadway by the Workhouse.

Brown loam and mottled clay have been dug in the outlier east of Wallington. In a poor exposure of the junction with the Chalk, seen in a road-side ditch at the southern end of this outlier, mottled clay immediately succeeded the basal layer of green-coated flints.

The coloured clays show here and there in the river-banks south of Fareham, and are or have been worked in a brickyard at Foxbury Point. South-east of this the outcrop passes into the Portsmouth district, in which the mottled clays are worked at Hilsea and Stamshaw, between 2 and 3 miles south of Cosham.

CHAPTER IX.

LONDON CLAY.

The full thickness of this formation seems not to have been proved in any of the local well-borings. It appears, however, to be about 250 feet at the boundary of the Bagshot Sands near Bishop's Waltham; and south-west of Fareham it may be not far short of 300 feet—the known thickness at Portsmouth. In some places there seems to be room for little more than 100 feet of strata between the Reading Beds and the Bagshot Sands, but local increment in the dips may be answerable for the apparent thinning.

The London Clay is here made up of evenly-stratified silty clays, loams, and loamy sands, with intercalated thin beds or seams of impure shelly limestone and of flint-pebbles. Concretions of clay ironstone and cement-stone, the latter often septarian, occur in open courses: some of the stiffer clays contain much selenite and pyrites. The warm brown colour which the London Clay usually exhibits at the surface of the ground gives way to dark grey, blue, and greenish tints below the zone of weathering. In the superficial parts of the Clay, which are alone to be seen in the great majority of the existing sections, fossils are seldom met with, save in the septaria and clay-ironstone concretions, which occasionally preserve samples of the characteristic marine molluscs. The small white nodules of calcareous matter known as race are often the only indication of the former presence of fossils.

A study of the dockyard excavations, and of the data afforded by borings, at Portsmouth, enabled the late C. J. A. Meÿer[1] to distinguish in the London Clay there "three series of strata," each beginning with a "zone of pebbles," and passing upward from stiff clays to sandy clays and sands.

The lowest of these series, which includes the pebbly and glauconitic Basement-bed, is about 100 feet thick. It was proved in the borings only, and nothing is said as to its fauna.

The middle series is 134 feet thick. Its lower half consists of stiff clay with pyrites. The upper half includes a clayey "zone of *Ostrea gigantica*," succeeded by "argillaceous sands with *Dentalium*"; and sands and shell-rock with *Lingula* occur at the top—the shell-rock, according to Meÿer, probably representing the Bognor Rock of Sussex.

The third and highest series, 50 to 60 feet thick, is characterised by clays and sands with *Cyprina*, in its lower half.

Meÿer distinguishes many minor lithological and palaeontological subdivisions. Probably most of these are of merely local value, but a group which includes the pebbly zone at the top of the second series has been recognised by Mr. J. W. Elwes near Fareham, in a section described below (p. 49).

The junction of the London Clay with the Reading Beds is usually even, and in places where the highest of the latter beds

[1] 'On the Lower Tertiary Deposits recently exposed at Portsmouth,' *Quart. Journ. Geol. Soc.*, vol. xxvii, 1871, p. 74–89.

is of a loamy nature there appears to be a passage from one formation to the other. An indistinct layer of flint-pebbles occurs at or a little above the surface of contact.

Notes of Exposures.

London Clay occurs in two tracts of country; one lying to the north, the other to the south, of the Portsdown line. To begin with the—

Northern Area:—At Wintershill House, south of Upham, a well-boring[1] proved 190 feet of clay and sandy clay, with carbonaceous matter and pyrites, above the Reading Beds. Though the nearest mass of Bagshot Sands is about 5 furlongs distant, conditions otherwise seem favourable for the making of a close estimate of the full thickness of the London Clay. The site of the boring is on a hilltop which falls short of the altitude locally appropriate to the geometrical projection of the Bagshot basal plane by about 60 feet. The addition of this figure to the 190 feet measured in the well gives 250 feet as the approximate total thickness.

The junction with the Reading Beds was seen by Mr. W. Whitaker in a small opening a furlong south-south-east of Wintershill Farm, the loamy Basement-bed there resting on mottled clay.

The exposure of the lowest beds in Messrs. Blanchard's brickyard at Bishop's Waltham has already been noticed (p. 42). About a quarter of a mile south-west of this a little brick-pit on the eastern side of the Avenue shows higher beds of brown clay, with cement- and clay-ironstones and soft race, passing down into dark-grey clay.

At Coppice Hill Brickworks, at the southern end of Bishop's Waltham, the section is as follows:—

		Feet.
Soil and stony loam.		
London Clay.	3. Brown sandy clay with a band of cement-stone near the middle	about 6
	2. Brown and grey laminated sandy clay ...	about 15
	1. Dark-grey stiff clay, with grains of glauconite, septaria, much selenite, and clusters of *Cytherea suessoniensis* Wat.	about 8

The lower limit of the section is close above the Basement-bed, a little of which is discernible in the sides of the adjacent road-cutting north of the yard.

The field-maps used by the Officers of the Geological Survey when revising the boundaries on the 6-inch scale bear notes of numerous surface-indications of the Basement-bed in the country south-east of Bishop's Waltham, and near Curbridge, but contain no mention of good exposures of London Clay; nor were any seen by the present writer, either there or in the area between the River Meon and the Portsmouth-Guildford road.

At Padnell a pit west of the disused brickyard formerly exhibited the Basement-bed, with the usual layer of black flint pebbles, resting on light-coloured Reading Sand. The junction

[1] W. Whitaker, 'Water Supply of Hampshire' (*Mem. Geol. Surv.*), 1910, 141.

is now obscured, the pit at present showing 8 feet of grey and brown clay, capped by a wash of pebbly loam.

Farther east there are small exposures of brown clay and loam in the water-courses in Havant Thicket, and in overgrown brick-pits west of Durrants and at Westbourne Common, but nothing of interest was seen in these places.

A well near the railway station at Havant passed through about 118 feet of brown and blue clay between the superficial deposits and the Reading Beds. The Basement-bed is there about 8 feet thick, and appears to contain two seams of pebbles—one of them described as "gravel" in the record.[1]

At New Brighton a well-boring proved 75½ feet of "blue London Clay, with layers of rock [? cement-stone] 26 and 28 feet down, and one 6 inches thick at the base."[2] In a boring made recently at Hermitage, east of Emsworth, 112 feet of the blue clay was found, with 2½ feet of "green sandy clay" and "rock" between it and the Reading Mottled Clay (*see* below, p. 90).

Southern Area.—The brickyard marked on the map south of Fareham has long been disused and the pits are now grassed over. North of Fareham, brown loams near the lower limit of the formation are exposed in the higher parts of most of the brick-and-tile yards opened in the northward-facing scarp between that town and Fontley. At the westernmost of these yards, in a copse three-quarters of a mile south of the Asylum, the workings show higher beds of mottled grey and brown silty clay; and still higher beds, of sandy clay, near the top of the formation, are dug in an extensive shallow working west of Uplands House.

About the year 1887, good sections in the middle and upper parts of the London Clay were displayed to the west of Fareham in cuttings on the Netley Railway, when that branch-line was in course of construction. These were examined by Mr. W. Whitaker for the Geological Survey, and by other observers, including Messrs. E. Westlake, H. Keeping, and J. W. Elwes, the last of whom published a detailed description of the Eocene and superficial deposits exposed in all the cuttings between Fareham and Netley, and a supplementary note on the fossils found in the London Clay near the first-named town.[3] The following particulars are taken from those parts of Mr. Elwes's papers which relate to the sections situated within the area of Sheet 316 of the one-inch Ordnance Map, that is to say, to the cuttings between Fareham Station and Titchfield Park Farm. The accompanying figure (8) is copied from a diagram by the same author, but some alterations have been made in the legend.[4]

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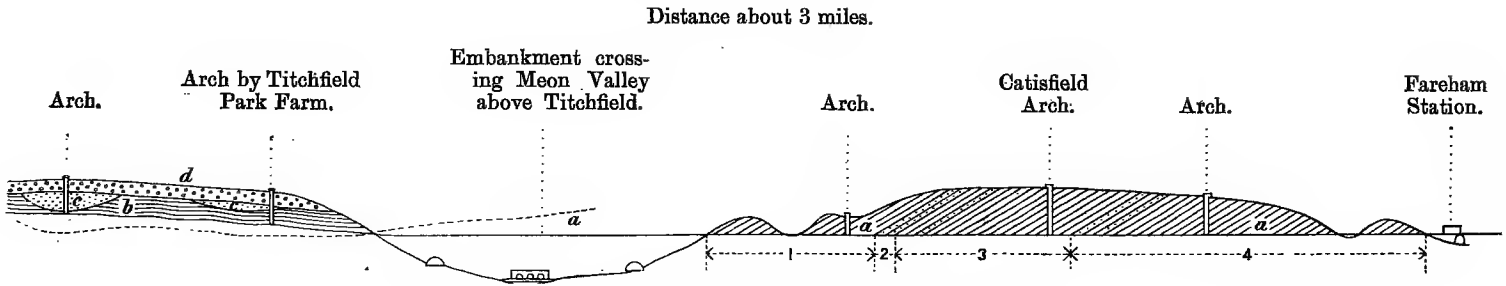
[1] 'Water Supply of Hampshire' (*Mem. Geol. Surv.*), 1910, p. 95.

[2] *Ibid.* p. 79.

[3] J. W. Elwes, 'Sections opened on the New Railway from Fareham to Netley,' *Pap. & Proc. Hamps. Field Club*, No. ii, 1888, pp. 31–39; and 'Additional Notes on Fossils at Fareham and Southampton,' *ibid.* No. iv, 1890, pp 80–83.

[4] *Pap. & Proc. Hamps. Field Club*, No. ii, 1888, facing p. 32. In the original figure (of which only part is reproduced) the London Clay beds are numbered inconsecutively in ascending order; whereas in the accompanying text, and in the fossil-list published in 1890, they are numbered consecutively in descending order. To obviate the resulting confusion, the latter sequence alone is used in the present abstract.

FIG. 8.—*Sections on the Netley Railway, near Fareham (after J. W. Elwes).*



a. London Clay (1–4, local divisions).
b. Bagshot Sands.
c. Bracklesham Beds.
d. Plateau Gravel.

Going westward from Fareham, the oldest of the London Clay beds observed on or adjacent to the course followed by the railway was exposed in a "digging for brick-earth, opened close to the station." The clay there contains "tabular claystone, abounding in shells," of which the most conspicuous are *Pectunculus* (*Axinaea*) *brevirostris* J. de C. Sow., *P.* (*A.*) *decussata* J. Sow., and *Pinna affinis* J. Sow.[1] Elwes states that "about eighteen other species have been found, an essemblage evidently characteristic of the London Clay, and of not a high horizon in it. It closely resembles the Bognor fauna." A list of these fossils is given below (pp. 50-52) under the heading 'Fareham Station.'

In the eastern part of the Catisfield cutting, north-west of the station, a higher bed was seen, composed of stiff brown clay (numbered 4 in Fig. 8), with *Ditrupa* at several horizons, and two seams of *Cyprina* and *Turritella imbricataria* (one of each) at the top.

The succeeding bed (3), whose lower limit comes into the cutting midway between the first or easternmost, and the second, or Catisfield, road-arch is stated to consist of blue-grey sandy clay, becoming more sandy upwards, and including occasional septaria, some of which contain wood bored by *Teredo*. Scattered in this clay are *Dentalium*, *Leda*, *Turritella*, and other fossils; and at its top, which was seen to the west of the Catisfield arch, *Ditrupa* occurs in masses.

The thin bed (2) is in some respects the most interesting of the series. It comprises two bands, each 1 foot thick, of black flint-pebbles in a matrix of dark sepia-coloured sandy clay with green grains, separated by a band of similar clay 2 feet thick. Remains of *Ostrea* occur abundantly, along with many other sorts of fossils, of which the most notable is *Terebratula bisinuata* Lam. —a form usually rare in the English Eocene, but occurring here in clusters, which Mr. Whitaker[2] likens to "miniature mussel-banks."

The western part of this cutting is in stiff blue clay (1), weathering green-grey and brown, and containing fossils in a bad state of preservation. A band rich in remains of *Pinna* occurs near the base, a few feet above the pebbly bed (2).

At the eastern end of the Park Farm cutting, on the farther side of the Meon or Titchfield Valley, light blue sandy clay was seen, followed by a few feet of loamy sand giving a passage into the Bagshot Sands.

Mr. Elwes shows that the group of strata comprising the *Pinna* band, bed (2), and the highest 3 feet (or thereabouts) of the sandy clay with *Dentalium* (3), has its analogue in the Portsmouth Dockyard section described by C. J. A. Meyer (*see* above, p. 45), where the *Terebratula* of the pebbly bed is replaced by the commoner brachiopod, *Lingula tenuis* J. Sow. This group appears to be about 10 to 12 feet thick in the Catisfield cutting. It is clearly in the upper part of the London Clay, and its precise

[1] A slab of this stone (Catalogued L. 5696) is preserved in the British Museum (Natural History).

[2] Excursion Report, *Proc. Geol. Assoc.*, vol. x, 1887, p. 138.

horizon may, perhaps, be inferred from the fact that a bed of clay with black pebbles—probably the equivalent of bed (2)—is reported to have been struck at a depth of 49 feet below the horizon regarded as the common limit of the London Clay and the Bagshot Sands in a well-boring at Titchfield,[1] about a mile distant. It should, however, be mentioned, that a boring at Stubbington House,[2] barely 2½ miles south of the cutting (and just beyond the boundary of the district covered by this memoir) proved three beds with flint-pebbles in the uppermost 166 feet of the London Clay; at levels respectively 25, 86, and 98 feet below the base of the Bagshot Sands. Which, if any, of these is to be correlated with bed (2) of the Catisfield section, it is hard to say.

List of Fossils.

The following list of fossils from the London Clay formerly exposed in the Netley Railway cutting north-east of Catisfield, and at Fareham Station, is taken from Mr. J. W. Elwes's "Additional Notes on Fossils at Fareham and Southampton" (*Pap. & Proc. Hamps. Field Club*, No. iv, 1890, pp. 80-82). In preparing the original list, Mr. Elwes was assisted by Mr. R. B. Newton of the British Museum (Natural History) and by Mr. H. Keeping. The nomenclature is in need of some revision, which the present writer, who has seen very few of the specimens on which the list was based, has decided not to attempt. The only alterations made here are in the arrangement and classification.

The beds in the Catisfield cutting are numbered (2 to 4) in descending sequence, and belong to higher parts of the formation than the fossiliferous horizon at Fareham Station. It will be noticed that some of the fossils named are not assigned to any definite bed or locality.

Fossils of the London Clay.	Catisfield Cutting.			Fareham Station.
	Bed 2.	Bed 3.	Bed 4.	
ANNELIDA.				
Ditrupa plana *Sby.*	—	×	×	×
Serpula	×	×		
Vermetus bognoriensis *Sby.* ...	—	—	—	×
BRYOZOA.				
Membranipora lecroixii *Sairg.*	×	×		
Polyzoa, 4 sp.	×			
BRACHIOPODA.				
Lingula tenuis *Sby.*	—	—	—	×
Terebratula bisinuata *Lmk.* ...	×			

[1] 'Water Supply of Hampshire,' 1910, p. 140. [2] *Ibid., loc. cit.*

Fossils of the London Clay—*continued.*	Catisfield Cutting.			Fareham Station.
	Bed 2.	Bed 3.	Bed 4.	
LAMELLIBRANCHIATA.				
Anomia tenuistriata *Desh.* ...	—	—	—	×
Ostrea gigantica *Sol.*	—	—	—	×
—— gryphovicina *S. Wood* ...	×			
—— flabellula *Lmk.*	—	×		
—— —— var. modicella *S. Wood*	—	×		
Pinna affinis *Sby.*	×	—	—	×
Arca tumescens *Edw. M.S.* ...	×			
—— sp.	×			
Pectunculus brevirostris *Sby.* ...	—	—	—	×
—— decussatus *Sby.*	—	—	—	×
Nucula gracilenta *S. Wood* ...	×			
Leda substriata? *Morris* ...	—	×		
Astarte tenera *Sby.*	—	—	—	×
Cardita brongniarti *Mantell* ...	—	×		
Corbula arnouldii *Nyst.* ...	×			
Panopaea intermedia *Sby.* ...	×	—	—	×
Pholadomya margaritacea *Sby.*	×	×		
Teredo	×	—	×	
Protocardium plumsteadianum *Sby.*	—	—	—	×
—— hornesi *Desh.*	—	×		
Tellina	—	—	—	×
Cyprina scutellaria *Lmk.* (planata *Sby.*)				
—— morrisii *Sby.*	—	—	×	
Cytherea orbicularis *Desh.* ...	—	—	—	×
—— obliqua *Desh.*				
—— suessoniensis *Desh.* (tenuistriata *Sby.*)	×	×		
SCAPHOPODA.				
Dentalium nitens *Sby.*	—	×		
GASTEROPODA.				
Bulla	×			
Phorus extensus *Sby.*	×			
Rimella lucida *Sby.*	×	×		
Trochita aperta *Sol.*	×	—	—	×
Turritella terebellata *Lmk.* ...	—	×	×	
—— imbricataria *Lmk.* ...	×	×	×	
—— —— vars.	—	—	×	
Aporrhais sowerbyi *Mantell* ...	×			
Cypraea oviformis *Sby.* ...	×			
Natica subdepressa *Morris* ...	×	×	—	×
—— labellata *Lmk.*	×	×	×	
—— 2 sp.				
Pyrula smithii *Sby.*	×	×		
Triton morrissii *Edw. M. S.* ...				
Cassidaria nodosa *Sol.*	×			
—— striata *Sby.*				

Fossils of the London Clay—*continued.*	Catisfield Cutting.			Fareham Station.
	Bed 2.	Bed 3.	Bed 4.	
Voluta elevata *Sby.*	×	×		
—— denudata *Sby.*	—	—	—	×
{ Leistoma globatum *Desh.* } { —— attenuatum *Edw. M.S.* }	—	×		
Chrysodomus bifasciatus *Sby.* ...	—	×		
—— crebrilinea *Edw. M.S.* ...	×	×		
—— sp. nov. ?				
Trophon tuberosum *Sby.* ...	—	×		
Pisania morrisii *Edw. M.S.* ...	×	—	×	
—— sublamellosa *Desh.* ...	—	×		
—— cymatodis *Edw. M.S.* ...	×			
—— transversaria *Edw.* ...	—	×		
Cominella				
Cancellaria laeviuscula *Sby.* ...	×	—	×	×
Murex subcristatus *d'Orb.* ...				
—— spinulosus *Desh.*	×			
Pleurotoma stena *Edw.* ...		×		
—— teretrium *Edw.*	×	×		
—— keelei *Edw.*	—	?		
—— terebralis *Lmk.*				
—— —— var. gyrata *Edw.* ...	×	×		
—— *near to* granata *Edw.* ...	×			
—— simillima *Edw.*	—	×		
—— flexuosa *Münster*	—	×		
—— *near to* wetherelli *Edw.* ...	—	×		
—— crassa *Edw.*	—	×		
CEPHALOPODA.				
Nautilus				
PISCES.				
Lamna, *teeth*				
Otolith	—	×		

CHAPTER X.

BAGSHOT SANDS.

In adjacent parts of Hampshire the relation of these Sands to the London Clay varies from place to place; some sections showing passage-beds between the two formations, others an abrupt change and unconformity, probably due to contemporaneous erosion in Bagshot times. Passage-beds have been observed in the district under consideration, but, owing to the paucity of critical sections, it is doubtful to what extent the other type of junction also is represented.

At or near the lower limit of the Bagshot Sands there are usually some flint-pebbles, arranged in one or more seams which occasionally expand into shingle-beds a few feet thick. Pebbly layers occur at other horizons, but these are thin and appear to be less persistent.

The bulk of the formation is composed of yellow and brown ferruginous sand (grey in the deeper wells), evenly stratified for the most part, and containing thin seams of laminated loam and pale grey pipe-clay. Small rolled pieces of lignite, resembling soft, lustreless charcoal and soot, are common in the highest part of the Sands. No other organic remains having yet been met with, the nature of the conditions under which the local Bagshot Sands were deposited is in doubt, though the writer inclines rather to the view that these conditions were marine.

This formation varies much in thickness—apparently between 15 and 60 feet—and tends to thin south or south-eastward. Like the London Clay, it occurs in two areas separated by Portsdown, each area including a part of the main mass of the sands in the Hampshire Basin, and sundry outliers.

Notes of Exposures.

Northern Area.—Along the Bagshot boundary south of Bishop's Waltham, Mr. W. Whitaker notes several surface-indications of pebbly sand, and a few road-side openings showing light-coloured sands; either with one or more layers of pebbles, as at Mincingfield and Grange Farms, or with thin seams of clay, as in a pit 250 yards north-east of Nations Farm. In the hillock (214 feet O.D.) half a mile east of the last-named farm there appears to be room for at least 40 feet of sandy beds above the London Clay.

At Shidfield there are several exposures in sand-pits and road-banks within a radius of half a mile from the church—notably along the highway to Bishop's Waltham. Two pits on the eastern side of this road show, respectively, about 10 feet of the lower beds, and the same thickness of the highest beds, of the formation. The lower working, just north of the little inlier of London Clay,

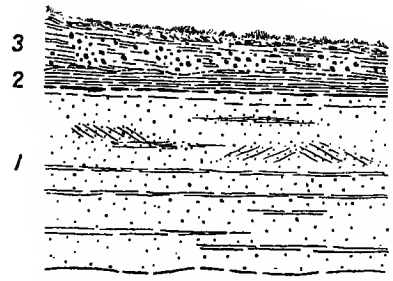
is in yellow sand traversed by interlacing bands of ironstaining. In the other pit, 300 yards to the north-east, the section (Fig. 9) is:—

		Feet.
Soil, loamy, passing into—		
Bracklesham Beds.	3. Brown ferruginous loam with bunches of black flint-pebbles	1 to 2
	2. Red-brown laminated loam with a thin layer of ironstone at the base ...	1
Bagshot Sands.	1. Brown, grey, and white sands, containing rolled pieces of clay and lignite, and interbedded with thin layers of laminated pipe-clay, and seams of small flint-pebbles	seen 8

Parts of the sand (1) are current-bedded. The pebbly loam (3) is disturbed, and may be a superficial reconstruction of Bracklesham-beds material.

FIG. 9.—*Section in Bagshot Sands and Bracklesham Beds, Shidfield.*

Scale: 1 inch = 8 feet.



1. Bagshot Sands. 2, 3. Bracklesham Beds.

The Sands make a considerable show at the surface in the neighbourhood of Shidfield, but their outcrop quickly narrows eastward, and along the right side of the Meon Valley, near Wickham, it is confined to a strip of ground one or two hundred yards wide. At Tapnage their yellowish sandy soil can be recognised, in the overgrown sides of the railway cutting, from the windows of a passing train; its light colour contrasting with the dull grey of the Bracklesham loams, which appear at intervals in slips along the line south-east of Botley Station.

At Curbridge, buff loamy sand was seen on the south side of the inn, and white sand by the stream to the south-east.

In the chain of outliers that extends for nine miles eastward of the River Meon, the thickness of the Bagshot Sands seems, as a rule, not to exceed 40 feet, though the lack of well-records, the absence of contours of altitude from the map, and the variable strength of the local dips make it difficult to form reliable estimates. In the Rooksbury outlier near Wickham, however,

there should be at least 60 feet of the Sands in some parts of the wooded ridge that supports West Lodge.

Brown and yellow sands, with or without clay-seams, are exposed in many places on the Rooksbury outlier, in road-banks as well as in the three sand-pits marked on the map. At least one well-marked pebble-bed occurs in the lower part of the formation on the eastern side, and has been dug for gravel in an old working five furlongs north-west of Wine Cross. The mapping suggests that the pebbles rest on an uneven surface, partly of older Bagshot sediments, partly of London Clay. It is likely that excavation hereabouts would reveal an unconformity, at the base of the Bagshots, similar to that observed by Mr. Whitaker near Otterbourne,[1] a few miles beyond the western boundary of this district.

Signs of a pebble-bed, in about the same stratigraphical position, appear in the north-western part of the Walton Heath outlier. Pits near the eastern side of the heath show 8 to 10 feet of stratified yellow, orange, and pale-grey sand of fine texture, with seams of grey sandy loam. The bedding is slightly undulate, and the prevailing southward inclination (of about 12°) which it exhibits is most probably the true dip, as the outlier of Bracklesham Beds a quarter of a mile to the south is at a considerably lower level.

Farther east, exposures of light-brown and yellow sands—usually loamy near the outcrop of the London Clay—occur in the banks of the roads and lanes on the Purbrook Heath and other outliers, but none of those seen by the writer calls for particular notice.

Southern Area.—The outcrops here are much hidden by superficial deposits, and at the time of writing but few exposures of interest are to be seen. The character of the Bagshot Sands in this part of the country is known, however, from Mr. J. W. Elwes's description[2] of the complete section observed by him, twenty-five years ago, in the then newly-opened railway-cutting by Titchfield Park Farm, north-west of Titchfield (*see* Fig. 8, p. 48). An abstract of his account of the succession there, supplemented by a few details taken from MS. field-notes by Mr. Whitaker, is given below.

At the south-eastern end of the cutting the highest part of the London Clay is in section—a sandy clay, light blue where unweathered. This is succeeded north-westward by about 6 feet of sandy passage beds, in alternate layers of light-green, grey, and brown tints, overlain by grey Bagshot sand free from clay.

The sand—apparently under 30 feet thick—is described as very fine and light-tinted, more or less stained by iron oxide from the overlying gravel, and "laid in horizontal beds, with little or no

[1] *See* C. Reid, 'Country around Southampton' (*Mem. Geol. Surv.*), 1902, p. 14.

[2] 'Sections opened on the New Railway from Fareham to Netley,' *Pap. & Proc. Hamps. Field Club*, No. ii, 1888, pp. 31-35.

false bedding." Close to the south-eastern end of the cutting the beds show an inclination towards the Titchfield (Meon) Valley, but this is less marked, or non-existent, to the north-west of the first arch, by Titchfield Park Farm.

About 100 yards north-west of that arch a small thickness of Bracklesham Beds comes in above the sand, and continues for a further 200 yards or so, the vertical succession in this part of the cutting being:—

		Feet.
Superficial loam, sand, and gravel		10
Bracklesham Beds.	Mottled light green and brown clay, "at one place mottled red, resembling somewhat the Reading Beds," 1 or 2 feet?	10
	Bed of flint-pebbles, thin	
	Clay, 1 foot	
Bagshot Sands—Light grey sand		

Near the second or Witherbed Lane arch, "the surface of the sand rapidly inclines west" or north-westward, a bed of lignite, 6 inches to 1 foot thick, coming in above it, followed by a mass of Bracklesham clay having two thin irregular seams of small flint-pebbles at the bottom. At the arch the Bracklesham clay occupies the floor of the cutting, unweathered parts of it there being of a bright blue colour; but at about 300 yards farther north-west its pebbly base reappears, succeeded, in descending order, by lignitic clay (here several feet thick), and by the sand, which continues without interruption to the end of the cutting, by Little Park.

The genetic character of the hollow occupied by the lignite and the Bracklesham clay—whether due to irregular deposition, flexure, or erosion—is not specified. Along the Meon Valley near Wickham there is evidence of a line of minor flexure which, were it prolonged south-westward, might very well intersect this part of the cutting (*see* p. 63). On the other hand, an erosive origin is suggested both by the shading in Mr. Elwes's diagram-section (Fig. 8, p. 48, of present memoir), and by Mr. Whitaker's reference to this feature as "a scoop." The lignite bed, which Mr. Whitaker describes as "peaty," may mark a boggy land-surface of late Bagshot age, but it is more likely to represent an accumulation of triturated drift-wood and other plant-débris, formed in an area of slack water, in early Bracklesham times. The argillaceous character of this bed north-west of the second arch, and its conformable relations with the overlying pebbly clay, incline one to refer it to the Bracklesham Series, rather than to the Bagshot Sands. According to Elwes, it is replaced by 5 feet of friable shaly clay in the next cutting to the west, in the area of the Southampton map.

Nothing of interest was seen on the narrow outcrops in the Meon Valley about Titchfield. Here the Sands are thin, but there seems to be room for more than the 15 feet (of "grey sand and black pebbles") reasonably assigned to them in the record of a well-boring made at the western end of that village.[1] Under

[1] 'Water Supply of Hampshire' (*Mem. Geol. Surv.*), 1910, p. 140.

Stubbington House, 2 miles to the south-east, their thickness appears to be about 25 feet.[1]

The few other exposures worth mentioning are those in the outlier near Uplands House, north-west of Fareham. At the southern end of the brickyard three furlongs west of the house, an old working shows some 10 feet of evenly bedded, yellow sand, near the base of the formation. A less thickness of similar sand is shown in a pit a quarter of a mile north of the hospital; and at the brickyard about the same distance north-east of that institution the junction with the Bracklesham Beds is seen in a section to be described in the next chapter (p. 60).

[1] *Ibid., loc. cit.*

CHAPTER XI.

BRACKLESHAM BEDS.

Though considerably thicker than the Bagshot Sands, which have a total outcrop-area of about the same size, these beds are less clearly exposed, for they have hitherto been but little exploited for brickmaking and other economic purposes in this part of the country; and being mostly of a loamy character, the banks of the roadways worn or cut in them are usually sloping and covered with vegetation. Failing these principal sources of information, one has to fall back on the records of local well-sections, of which only five relating to the Bracklesham Beds are known to the writer.

In adjacent parts of Hampshire, to the west, the full thickness of the Bracklesham Beds may be about 400 feet, but in the area under consideration an unascertainable though probably large proportion of the formation, as originally developed, is missing; and it is doubtful if the part that remains is anywhere more than 200 feet thick. The highest known measurement, about 170 feet, is afforded by a well-boring at Cold Harbour, near Wickham, in that part of the district where these beds are inferred to be best preserved.

In surface exposures the junction with the Bagshot Series is marked by an abrupt change from the light-coloured sand of that formation to a darker red-brown, sandy-clay, having flint-pebbles scattered through it, or arranged in seams a little above its base. The iron oxide responsible for the warm brown colour of the bottom-bed seems to result from the decomposition of pyrites rather than of glauconite, for in accounts of borings and other deep excavations the basal part of the Bracklesham Beds is described as having a blue tint.

The rest of the formation is made up of greyish shaly clays and laminated loams, with subordinate beds of white and speckled greenish sand, and bands of lignite. Shells of marine molluscs, which are common at various horizons in the country to the south and west, doubtless occur here also, though it does not appear that any have been observed.

Notes of Exposures.

These will be divided under the same headings as in the last chapter.

Northern Area.—The pebbly bottom-bed and its junction with the Bagshot Sands are distinguishable in road-banks by Calcot Farm, north of Curdridge Common. In a well at Oaklands, on the eastern border of the Common, 96 feet of clay and sandy clay was found above the Bagshot Sands. At Kitnocks, on the southern side of this Common, a boring passed through 80 feet of

yellow, red, and blue clay, and ended, 6 feet lower, in dark green or black sand (drying to light grey).[1]

At Shidfield the junction with the Bagshot Sands is well seen in a pit opened in a small unmapped outlier, half a mile north-north-east of the church; the section there is described above (p. 54). According to the map, the Parsonage at the southern end of this village is on Bagshot Sands, but a boring made there, in the bottom of an old well 21 feet deep, passed through a further 23 feet of bluish and greyish loamy beds before reaching sand that could be safely referred to that formation.[2]

Dark grey clays and loams are exposed in small slips on the sides of the railway cuttings south-east of Botley Station.

At Cold Harbour, on the ridge west of Wickham, the well-boring to which reference has been made proved the following succession[3]:—

		Thickness.
" Bracklesham Beds (170 feet).	Old well. Sandy bottom	90
	Sandy clay	20
	Sand, as above	3
	Red clay	2
	Blue clay with aandy veins... ...	2
	Clay	8
	Clay, but more loamy and with large pebbles (2 or 3 inches diameter)...	5
	Clay, as above, but browner, and with iron pyrites	27
	Clay, as above, but with small pebbles	8
	Rather darkor, with pebbles and sand	2
	Clay, like the 27 feet bed, above ...	3
" Black (Bagshot) Sand, with irregular sngular (?) pebbles.		
Water		1 "

Most of the outliers east of the River Meon appear to be mere patches of loam. The larger masses, at Southwick and west of Purbrook Heath, have some slight relief, and may be 30 to 40 feet thick. Poor road-bank exposures of sandy clay were noted in several places, but not any clear sections.

Southern Area.—The small outlier north-west of Fareham is worked in a brickyard a quarter of a mile north-east of the hospital. The succession seen in the western part of the pit there (Fig. 10, p. 60) is:—

		Feet.
	Soil, stony loam.	
Superficial Deposits.	4. Light brown loam	2
	3. Interbedded flint gravel, sand, and brown sandy loam	4
Brackleaham Beds.	2. Mottled red-brown and grey loam, with scattered pebbles in the lower part ...	2
Bagshot Sands.	1. Brown sand, evenly bedded, with continuous seams of brown clay	seen 10

The sections of the lowest of the Bracklesham Beds formerly shown in the Titchfield Park Farm cutting on the Netley Railway, north-west of Titchfield, were noticed in the last chapter. The

[1] 'Water Supply of Hampshire,' 1910, p. 65.
[2] *Op. cit.*, p. 126. [3] *Op. cit.*, p. 142.

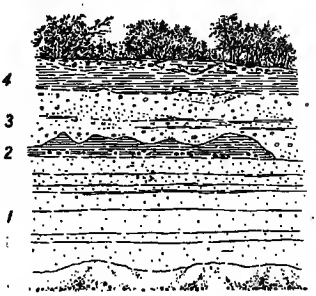
higher beds which come in to the south of the railway are largely arenaceous—apparently much more so than those in the corresponding stratigraphical position north of the Portsdown line.

An old pit in a copse three-quarters of a mile west of Segenworth shows 8 feet of current-bedded brown and white sand of fine texture. Mr. Clement Reid notes green shaly clay in the bed of a brook west-north-west of Titchfield Abbey, and dark green sand at Windmill Farm, about 1¼ miles west of that place.

In the account of a well-boring made at the western end of Titchfield, the lowest beds of the Bracklesham Series are described as "blue loamy sand" and "blue clay."[1]

FIG. 10.—*Section in Bagshot and Bracklesham Beds, and Plateau Gravel, near Fareham.*

Scale: 1 inch = 16 feet.



1. Bagshot Sands.
2. Bracklesham Beds.
3. Plateau Gravel.
4. Loam.

Yellow and brown loamy sand appears along the course of the brook at Crofton, and is dug 200 yards south-east of the church.

At Hill Head, about a mile beyond the boundary of the district south of Titchfield, the low cliffs facing the Solent show pale greenish-grey glauconitic sand; and fossiliferous sands and loams with *Corbula pisum* J. Sow., *Pecten corneus* J. Sow., *Turritella sulcifera* Desh., &c., appear on the foreshore near Stubbington Lane End, to the south-east of this.[2]

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[1] *Op. cit.*, p. 140.

[2] O. Fisher, 'On the Bracklesham Beds of the Isle of Wight Basin,' *Quart. Journ. Geol. Soc.*, vol. xviii, 1862, pp. 77–79.

CHAPTER XII.

TECTONIC STRUCTURE. LAND FORMS.

Little is known concerning the history of this part of the country from Bracklesham times down to the close of the Oligocene period. It is highly probable that the Bracklesham Beds were succeeded by the Barton and Headon, for these still occupy a considerable area of the Hampshire main-land in the Southampton district, immediately to the west; and it is hardly less likely that some, at least, of the later fluvio-marine deposits which bulk so largely in the Isle of Wight, between five and ten miles distant to the south, also were once represented here; but no certain indication of the former presence of any of these rocks has yet been recognised in the local superficial deposits.

During the Eocene and Oligocene periods the eastern part of the Hampshire Basin seems never to have risen much above sea-level. When not submerged, it probably formed an expanse of flat, low-lying country; and for all evidence to the contrary, this may have been its condition in the earlier ages of the Miocene, when the 'posthumous Armorican' earth-movements, which were to revolutionise the structure and topography of the southern part of the English region, may have begun to make themselves felt.

These disturbances have left their marks on the rocks of the Fareham district in sundry folds and fractures, the more important of which will be briefly described in the present chapter.

The general structure of the district can be inferred from the arrangement of the boundaries of the Cretaceous and Eocene formations on the map, and from the diagram-section through Butser Hill and Farlington engraved on the lower margin of Sheet 316. The prevailing southward to south-south-westward inclination of the strata, which is shown in that section, constitutes the dominant element in the local tectonics: it is part of the regional dip from the Wealden anticlinorium towards the trough of the English Channel, and though probably initiated in Eocene times, it is mainly of late Tertiary development.

Running athwart the southward dip, and modifying it in varying degrees, there are several lines of folding which are marked on the accompanying sketch-map, Fig. 11. The existence of the more important of these has long been recognised, and some account of them has been given in former Memoirs of the Geological Survey, as well as in earlier papers by P. J. Martin, C. Evans, and other authors.[1]

[1] *See* C. Reid and A. Strahan, 'Geology of the Isle of Wight' (*Mem. Geol. Surv.*), 1899, pp. 239, 240. A. J. Jukes-Browne, 'Cretaceous Rocks of Britain' (*Mem. Geol. Surv.*), vol. i, 1900, pp. 7, 8.

P. J. Martin, 'On the Anticlinal Line of the London and Hampshire Basins,' *Philos. Mag.*, ser. 4, vol. xii, pp. 447, 448.

C. Evans, 'Geology of the neighbourhood of Portsmouth and Ryde,' *Proc. Geol. Assoc.*, vol ii, 1873, pp. 61–64, 173.

J. W. Elwes, 'London Clay in the vicinity of Southampton,' *Geol. Mag.*, 1884, p. 550.

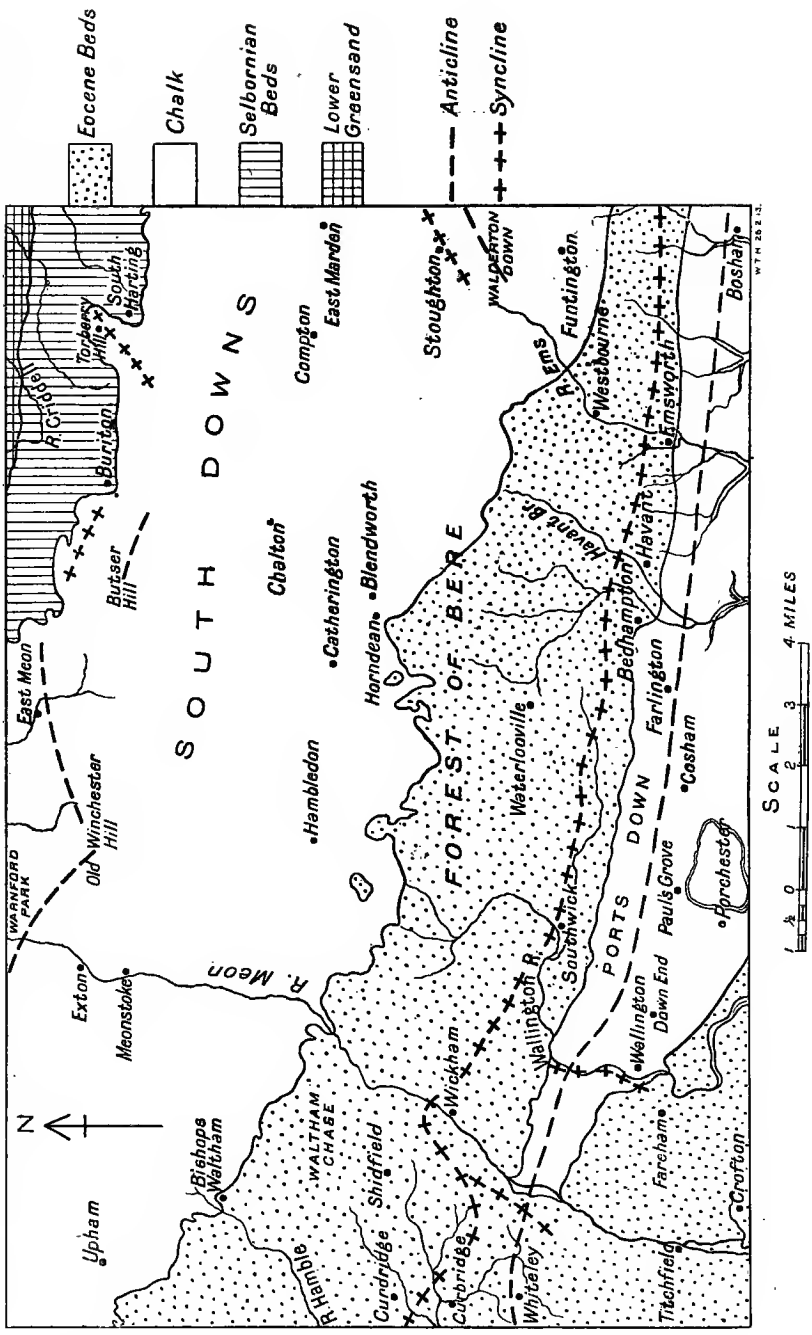

FIG. 11.—*Sketch Map of the Fareham District, showing the approximate position of the principal lines of Folding.*

To begin with those on the north:—Some obscure flexures occur along the line of the Chalk escarpment between South Harting and Butser Hill. Their effects are seen in the north-eastward projection of Chalk boundary at Torberry Hill, and in the northward

dip of the Chalk in the quarries about Buriton. Torberry Hill lies in a slight syncline, and the small upfolds east and west of it are probably of periclinal type. The structure of the country between Buriton and Butser Hill is difficult to interpret from existing data, but it may be said that there is evidence of a short anticlinal axis running from the northern part of Heath Down to the southern end of Butser Hill, and of a roughly parallel synclinal axis crossing the line of the Portsmouth-Guildford road near the 15th milestone.

The Winchester anticline first becomes clearly distinguishable in the neighbourhood of Barrow Hill, near East Meon, a little to the east of which village it brings up the Selbornian Greensand in a small inlier. Like the majority of the southern English anticlines of Tertiary age, it is transversely asymmetrical, with the stronger dips on the northern limb. From East Meon this fold runs rather south of west to Old Winchester Hill, where there are signs of a break in its continuity, the axis apparently shifting a few hundred yards to the south, and certainly adopting a north-westward trend, which is maintained to the northern boundary of area under consideration. It is in the latter section of its course, between Old Winchester Hill and the River Meon near Warnford Park, that the plication is most pronounced, the dips of 15° to 18° or 20° there noted in the northern limb being higher than any so far observed elsewhere along this line of flexure.

South of the Winchester axis, for a distance of from 7 to 9 miles, the planes of bedding dip gently southward into the parallel syncline of Chichester, whose course through the middle of the district is plainly marked by the belt of Eocene strata preserved in its trough. East of Havant the principal axis must nearly coincide with the line of the London, Brighton, and South Coast Railway (*see* Fig. 16, p. 77); while its path west-north-westward of that town is roughly marked by the chain of Bagshot and Bracklesham outliers extending through southern part of the Forest of Bere.[1] In the vicinity of Wickham there are signs of some structural complication which would be more intelligible if the local contours of altitude were not missing from the map. It is fairly evident, however, that the syncline deepens rather abruptly to the west of the River Meon, and that the axis is deflected southward, but soon resumes its west-north-westward trend.

Near the eastern limit of the district the Chichester syncline is much reduced in width, owing to the approximation, on its northern side, of a group of independent flexures, whose south-western termination is seen in the anticlinal ridge of Walderton Down and the complementary trough of the upper Ems Valley, near Stoughton. These flexures become of more importance in the

[1] In the writer's 'Country around Alresford' (*Mem. Geol. Surv.*), 1910, p. 73, the existence of a synclinal axis near Baybridge (Sheet 299) is suggested. Better acquaintance with the country south of this village has dispelled the false impression on which that suggestion was based.

adjoining area of Sheet 317, where the anticline of Walderton appears to be represented by that of West Dean.[1]

The Portsdown anticline runs through the southern part of the district with the same trend as the Chichester syncline to the north of it. For a distance of seven miles westward of Bosham the rocks affected are so much hidden by superficial deposits that the position of the axis is in doubt: probably, however, it does not depart widely from a straight line drawn from Bosham to Farlington. West of the latter village it runs across the southern slope of Portsdown (*see* Fig. 2, p. 26), near Cosham and Paul's Grove, to the neighbourhood of Nelson's Monument, and thence west-north-westward to Knowle Farm, beyond which place it bears westward to the boundary of the district, near Whiteley. As far as can be seen, the plication is of a gentle order, the dips in the more strongly inclined northern limb commonly amounting to about 12°, and seldom attaining a higher angle.

A cross-flexure traverses the Portsdown fold approximately along the line of the Wallington River north of Fareham; and another, connected with the disturbance near Wickham, mentioned above, occurs in the Meon Valley near Knowle Farm. The result in each case is a rather quick downward displacement of the beds on the west (evidence of faulting in the opposite sense, mentioned below, notwithstanding), followed, apparently, by a slower and incomplete recovery.

Professor C. Barrois' suggestion,[2] that the chalk which dips northward in the higher part of Portsdown is separated by a fault from that inclined in the opposite direction near Fareham, receives some support from recent observations by Mr. R. M. Brydone. In the Clapper Hill pit, north of the waterworks at Wallington, the latter author finds evidence of a fault, which has an estimated downthrow of at least 40 feet to the east, and which he ventures to map as extending across the Portsdown area, along the line of the Wallington River.[3] But the visible faults in this and other parts of the district are, individually at least, of little importance, and involve displacements of no more than a few feet. They are mostly of the normal type. A group of little step-faults, shown in a quarry north of Porchester, has already been noticed (p. 27, Fig. 3).

Besides the faults, and the commoner sorts of fracture known as joints and master-joints, some of the quarries in Portsdown

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[1] *See* C. Reid, 'Country near Chichester' (*Mem. Geol. Surv.*), 1903, pp. 2, 26.

[2] 'Recherches sur le terrain Crétacé . . . de l'Angleterre, &c.,' 1876, p. 34.

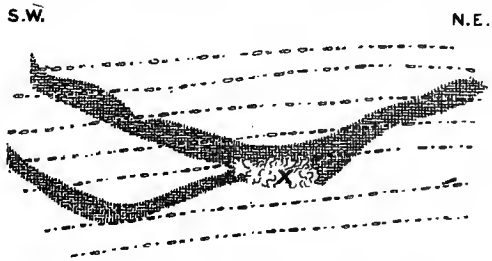
[3] 'Stratigraphy of the Chalk of Hants,' 1912, pp. 32, 33; and map.

His argument for the extension of this fault across the Portsdown chalk, and for its pre-Tertiary age, rests mainly on the assumption that the Mucronata Zone is unrepresented on the western side of the Wallington Valley north of North Fareham, where, unfortunately, there seem to be no critical sections.

Along the boundary of the Reading Beds, between Wallington River near White Dell Farm and the River Meon near Knowle Farm, the Mucronata Beds, if not wanting, must be much thinner than in the immediate vicinity of Fareham; but the northward overstep of the Chalk by the Eocene (*see* p. 41, of present memoir) seems competent to account for this thinning, without the aid of a pre-Tertiary fault.

exhibit belts of cleaved, slickensided, and minutely-shattered chalk, from a few inches to a foot or two in width, disposed as a rule at high angles to the horizon. The eye is drawn to them by their greyish tint, which is due to the hachure-like shading of a multiplicity of little fissures. They doubtless mark zones of exceptional stress during periods of earth-movement, but their structural and chronological relation to the folding is not apparent. Good examples are to be seen in the western of two quarries north of Porchester Station, in the quarry north of Paul's Grove, and in that south of Offwell Farm near Southwick.

FIG. 12.—*Cleavage-bands in the Chalk, Porchester.*



In the Porchester section, a branching belt of cleavage, roughly represented in Fig. 12, dips about north, while the planes of cleavage within it dip at high angles southward, except near the point marked **X**, where they are contorted and there is some development of slickensides. The cleavage-belt runs obliquely across the slightly undulate bedding, which dips about 5° south-westward; and it is unaffected by a small normal fault (not shown in the figure) on the western face of the quarry.

LAND FORMS.

In the absence of sediments which can at present be safely referred to the Miocene and Older Pliocene, it is hard to say what vicissitudes this part of the country experienced during the development of the tectonic features above described. Much of the local history of those times may be inscribed in the details of the existing topography, but the study of land-forms is not yet sufficiently advanced to enable one to decipher more than a few passages of the record, and these often are difficult to collocate.

As may be gathered, to some extent, from an inspection of the map, the character and arrangement of the larger physiographic features are, for the most part, in harmony with the underground structure. The prevailing slope of the country agrees with the prevailing southward dip of the rocks, and the bulk of the surface-drainage runs off in the same direction. The bottom of the broad Chichester syncline, too, is appropriately marked by a belt of comparatively low ground, between the South Down and Portsdown uplands in the anticlinal areas to the north and south. Furthermore, in this synclinal lowland, west of Havant, the southward drainage undergoes a large measure of concentration, and the few channels by which it escapes across the anticlinal line of Portsdown correspond with tectonically low points in that fold.

Taken collectively, these facts strongly suggest that the existing physiography has been evolved, under subaërial conditions, from that originally determined by the tilting and folding of the strata.

Exception must be made, however, in the case of the coastal plain, and especially of that part of it which lies to the east of Havant, where all topographic expression of the folds in the solid rocks has been obliterated by marine abrasion in Pleistocene times. The drainage of this tract, unlike that of the country west of Havant, shows little sign of concentration in the area of the Chichester syncline: it is of purely transverse type.

Although the rest of the district seems never to have been subjected to marine planation since the development of the Miocene folds, it may well have been worn low by rain and rivers, and have been re-elevated, more than once before the end of the Pliocene period; for, close as are the relations subsisting between the broader tectonic and topographic features, it is certain that much of the existing relief is immediately the outcome of differential erosion, whereby (among other results) the outcrops of the more resistant beds have been brought into prominence as ridges and ranges of hills.

The principal ridge-making strata of the district are, the Selbornian Malmstone (Upper Greensand), the group of Chalk Zones from *Rhynchonella cuvieri* to *Micraster coranguinum* inclusive, the Zone of *Actinocamax quadratus*, and the London Clay-Bagshot Sands. Developed as a rule on the limbs of the folds, the features to which they give rise conform more or less closely to the familiar geomorphic type which is defined by an escarpment and a dip-slope: a type that finds its sharpest expression in the so-called 'terrace' of the Malmstone.

The strong but discontinuous feature which marks the oncoming of the Quadratus Zone, along a line drawn through Compton Down, Broadhalfpenny Down, Shepherd's Down, and Upham, was noticed by William Topley,[1] who traced its continuation in the Sussex Downs for many miles eastward of this district. Want of personal acquaintance with the country prevented him from indicating its course westward of Broadhalfpenny Down with certainty, though one of the alternative routes he suggests agrees with the actual line of its extension in that direction. Contrary to his impression, however, the feature can be traced across the Hampshire Chalk country, to the Wiltshire boundary near Middle Winterslow. Whether this "well-marked line of hills running parallel with the escarpment" of the Chalk has or has not the same significance throughout its course in the South Downs of Sussex, is a question that remains to be decided.

There are one or two points connected with the drainage of the Chalk country to be noticed before concluding this chapter.

East of Butser Hill the crest of the South Downs is broken by a succession of deep notches or gaps, which are situated at the upper ends of the larger dip-slope valleys, and in many cases

[1] 'Geology of the Weald' (*Mem. Geol. Surv.*), 1875, p. 266.

are cut down into the Lower Chalk. From the depth of these gaps—between 150 and 300 feet—it might be inferred that the dip-slope valleys, to whose decapitation they bear witness, once extended many miles northward of the present escarpment of the Chalk; but this is negatived by the very frequency of the gaps, which implies the existence of a water-parting at a short distance to the north at the time when the determining valleys were marked out, and by the non-occurrence in them of detritus of rocks older than the Chalk.

West of Butser Hill no such gaps are seen, and it is evident that the bulk of the drainage of the country along the line of the Winchester anticline, between Butser and Old Winchester Hills, has long been carried off northward, as at the present day. The well-marked anticlinal vale of East Meon and Whitewool possesses three drainage outlets on the north, namely, at East Meon, west of Drayton Down, and north of Whitewool; but the second of these carries little water, and is threatened with complete loss of function owing to the growth of the catchment-areas pertaining to the first and third outlets, on either side.

From the adjacent anticlinal vale of Warnford and Exton the only drainage outlet now in use is to the south, in the Meon Valley at Meonstoke. A dry gap, marking a former northward outlet, however, occurs (just beyond the boundary of this district) to the east of Warnford Park, on the line of the Meon Valley Railway. The curious course pursued by the River Meon between East Meon and Warnford is discussed in the memoir on the Alresford Sheet of the Geological Survey map (p. 74). It is there suggested that the Upper Meon, above Warnford, was originally a tributary of the Itchen, and that its present connection with the Lower Meon, below that village, is due to a capture effected by the last-named stream, which had the advantage of a more direct route to the sea.

On the Portsdown anticline conditions have been unfavourable, if not for the formation, at least for the preservation, of longitudinal valleys in the Chalk, and the sole rudiment or vestige of such observed by the writer is the shallow embayment in the southern face of the Down about half a mile north-west of Paul's Grove. Mention may here be made of the fact that it is to the west only of this embayment that the transverse profile of Portsdown at all faithfully reflects the curvature of the anticline. The higher and more imposing part of the ridge, to the east, belongs entirely to the northern limb of the fold, as Caleb Evans recognised many years ago.

The essential features of an anticlinal vale are discernible, on the same line of folding, in the basin of the brook that drains the lozenge-shaped area of Reading Beds around Whiteley, near Curbridge.

The form of the ground near the southern limit of the district has been largely determined by marine erosion, whose effects it will be more convenient to notice in a later chapter (*see* pp. 79-81).

CHAPTER XIII.

CLAY-WITH-FLINTS.

Under this heading are grouped a number of unstratified superficial deposits, occurring in ill-defined patches on the Chalk in the northern part of the area. They consist of brown loams and red-brown clays, containing abundant unworn flints, a sprinkling of flint-pebbles, and occasional pieces of iron-sandstone. They are evidently a product of the disintegration of the Tertiary beds and the Chalk, and although the precise nature of the process by which their constituents were blended is not well understood, little hesitation need be felt in assigning these accumulations to the subaërial class.[1] To judge from their distribution, they are of various ages; some of them almost certainly dating from the Pleistocene period; others appearing to be a good deal older.

On the map, the patches of Clay-with-Flints look like relics of a once-widespread sheet covering the Chalk. Such they may be; but it is as well to point out that this appearance is due in no small degree to the unnaturally (and unavoidably) sharp rendering of the boundaries, which suggests a possibly false analogy between the several patches and the outliers of a 'solid' formation. In its lack of definite boundaries, its rapidly varying thickness, and in the way it adapts itself to the contours of the underlying rock, the Clay-with-Flints resembles soil—from which, indeed, it often is hardly distinguishable.

The majority of the accumulations large enough or sufficiently distinct to be shown on the map occur on the more gently inclined grounds between the valleys in a belt of country which follows the boundary of the Eocene strata, and which coincides pretty closely with the outcrop-surface of the *Actinocamax quadratus* Zone. The rest are less regularly distributed over the high grounds above Buriton and around the village of East Meon.

Some of the deposits near the Eocene boundary appear to occupy positions formerly held by projecting masses or by outliers of the Reading Beds, for the surface on which they rest does not depart appreciably from that on which those beds were laid down in Eocene times. Farther out on the Chalk, the Clay-with-Flints falls well below the inferred position of the Eocene basal plane; its divergence from that datum probably amounting to some hundreds of feet in the case of the patches near the crest of the South Downs. There, it will be observed, denudation has so far reduced the thickness of the Upper Chalk, that there is commonly less than 100 feet of it below the Clay-with-Flints; while in places near East Meon the latter rests on the Middle Chalk.

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[1] *See* A. J. Jukes-Browne, 'The Clay-with-Flints, &c,' *Quart. Journ. Geol. Soc.*, vol. lxii, 1906, pp. 132–164.

Probably this reduction was partly effected in early Eocene times, and is, to some extent, the expression of the northward overstep mentioned on p. 41; but that it was not wholly, nor mainly, accomplished at that epoch is to be inferred from the actual existence of stratigraphical equivalents of much of the missing chalk, in the shelter of a post-Eocene syncline, at points less then a mile north of the patches of Clay-with-Flints on the ridges west of East Meon.[1]

A few notes on the character of some of the deposits are given below.

At Upham, typical reddish Clay-with-Flints is shown to a depth of 4 or 5 feet in road-banks near the church. South of the village a cutting on the road towards Stake's Farm exhibits stony loam resting on chalk with a remarkably even junction.

Around Street End, north of Bishop's Waltham, the Clay-with-Flints contains much brown loam; and the same may be said of the patches at Upper Swanmore.

About Hoe Cross, too, there is a good deal of light-brown loam—very stony in places; though red clay, with thickly-scattered bleached flints, is exposed in an old working north-west of the cross-ways.

South of Hambledon the Chalk has a thick capping of stony clay, which overlaps, and seems to merge into, the clayey Reading Beds at Rushmere and north of Denmead Farm.

Deposits of more loamy character occur about Pithill and Broadway Farms; also to the east of Lovedean, to the north of Hinton Manor House, and on Broadhalfpenny Down; while the red-clay type is well developed on the Hinton Farm ridge, at Catherington, and about Blendworth. At Catherington the banks of the pond south-west of the church give a section about 5 feet deep. The form of the ground suggests that the Clay-with-Flints is thicker than usual hereabouts. Pieces of fine-grained iron-sandstone were noted in a road-bank south of the western church at Blendworth.

Stony clay of small thickness spreads down the southern slope of Windmill Hill, and thicker deposits of similar character occur on the ridges between Idsworth and East Marden.

The accumulations on the high grounds around East Meon appear to be composed largely of red-brown, stony clay.

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[1] *See* 'Country around Alresford' (*Mem. Geol. Surv.*), 1910, pp. 53, 56; also R. M. Brydone, 'Stratigraphy of the Chalk of Hants,' 1912, zonal map.

CHAPTER XIV.

RAISED BEACH, GRAVELS, AND BRICKEARTH.

Unlike the Clay-with-Flints, the superficial deposits that remain to be described show more or less distinct signs of having been laid down in water. They are mapped in five groups, which are described in the legend of Sheet 316 as Raised Beach, Plateau Gravel, River and Valley Gravel, Brickearth, and Alluvium. Of these, all except the last-named will be considered in the present chapter.

The writer does not know what criteria were employed in the discrimination of the gravelly classes of superficial deposits for mapping purposes. The distinction drawn between Plateau Gravel, on the one hand, and Raised Beach and Valley Gravel on the other, appears to be rather too arbitrary; and it may be questioned whether some of the deposits assigned to the first of these groups would not have been more fitly referred either to the second or to the third. As, however, it seems impossible to devise a really satisfactory scheme of classification, it will be best to describe the above-named four groups as they stand, and then to indicate the probable chronological sequence of the deposits which they jointly comprise.

Raised Beach.

According to the map, this comprises two small patches on the southern slope of Portsdown east of Fareham; one on either side of the road from Downend House to Nelson's Monument. The ground they occupy is estimated to be a little below 100 feet O.D., and has a pronounced southward inclination, across which the raised beach deposits run obliquely. The existence of the patch mapped on the west side of the road seems open to question. The writer saw no sign of a pit in the stony loam of the arable land on its site, nor any arresting peculiarity in the form of the ground.

The character of the deposit on the eastern side of the road is known from the late Sir J. Prestwich's description of the section seen by him in a pit "on the north side of East Cams Wood"—now called Down Coppice.

"The pit," he writes,[1] "is a shallow arc, and presents the following section:—

"*a*. Grey earth and sand, with angular and rolled flints, 0 to 2 feet.
"*b*. Light-coloured laminated sands, with seams of shingle ... ... } 4 to 6 feet.
"*c*. Light-coloured coarse flint shingle, with a few whole flints ... ... }
"*d*. Chalk rubble, patches of.

"The beds *b* and *c* constitute a true shore-shingle, composed of rolled and imperfectly rounded flints, imbedded in a matrix of light-coloured sand and loam, very different from the ochreous subangular flint-gravel

[1] 'On the Presence of a Raised Beach on Portsdown Hill, &c.' *Quart. Journ. Geol. Soc.* vol. xxviii., 1872, p. 38.

at the base of the hill. In the shingle are a few Tertiary flint-pebbles, and not a few large unworn flints, with a number of sharp angular flint fragments. The only foreign material I found was a fragment of reddish quartzite. I saw no organic remains of any description. . . . . There can be no mistake made about the character of the shingle. It is not so rounded as the Tertiary flint-pebbles, which can be readily distinguished amongst it, while it is far more worn than the subangular gravel at the base of the hill. In places there are signs of disturbance, as though from the effects of ice-action, ... "

The deposit is no longer well exposed. Its claim to be regarded as a relic of raised beach rests mainly on its resemblance to other and fossiliferous deposits, which occur at intervals along the landward margin of the coastal plain of Hants and Sussex, between this point and Brighton, and which have been described by several writers.

It should be mentioned here that Prestwich recognised another remnant of raised beach in the gravel at Westbourne Common. This is mapped as Plateau Gravel, and will be noticed under that heading (p. 72).

Plateau Gravel.

This group comprises a number of scattered deposits resting on the Eocene Beds at various altitudes between 30 and 315 feet above Ordnance Datum. The higher and more typical spreads cover flat-topped hills and ridges on the principal water-partings; the lower occupy similar flats on the minor divides, and occur in terraces and inclined sheets on the sides of the river-valleys.

The gravel is composed of angular and subangular flints, with some admixture of flint-pebbles, flat pieces of iron-sandstone, and rounded sarsens (or greywether sandstones) mostly of small size.[1] Its thickness seldom exceeds 12 feet, and is usually much less. The more sandy deposits are commonly stratified and current-bedded, in their lower parts at least, but these structures are rarely apparent in the gravels that contain much loam.

With a few exceptions presently to be noted, the local Plateau Gravels are, or appear to be, old river-deposits, or the débris of such rearranged under subaërial conditions. As far as the writer is aware, they have yielded no flint implements, but it is highly probable that Palaeolithic tools will eventually be found in them.[2]

Taking first the deposits north of the Portsdown line, and beginning on the west:—

A thin spread of little-worn flints in loamy sand caps the flat summit of the ridge (160 to 175 feet O.D.) in the northern part of Curdridge Common. The gravel seems to be of rather fine texture. There are no sections.

[1] Sarsens more than 6 inches in diameter seem rare in this district. The writer noticed only four road-side blocks of greater size: two at the farm half a mile north-north-west of the church at Barn Green (Forest of Bere); one at the road-turning just below the 'S' of 'Soberton Heath' on the map; and another opposite the smithy at the eastern end of East Meon. The last, which is much the largest, is a slab about 5 feet long by 1 foot thick, composed of flint pebbles in a matrix of light brown sandstone. It is of a type common in the area of the Alresford map (Sheet 300). The other three are of brown sandstone.

[2] *See* Postscript, p. 81.

The deposits at about the same height on the edge of the Meon Valley west of Wickham are of a more sandy nature. About 3 feet of gravel, with signs of bedding, is shown in the pits marked on the map north-east of Park Place.

Fine, ochreous gravel, containing many Tertiary flint-pebbles, is exposed in a small ponded excavation on the eastern side of the road along the top of the Rooksbury ridge, at a point a little more than a quarter of a mile south-west of West Lodge. The gravel here is between 300 and 315 feet O.D., and is by far the highest of the Plateau group in the district. The adjacent patches on the slopes in West Walk look like washes from the top of this ridge.

Bere Farm, south-west of Soberton Heath, is on a plateau rather below 240 feet O.D., and about 120 feet above the River Meon. Loamy gravel has been dug in a shallow pit at the northern end of the flat.

In the Forest of Bere there are several small loamy patches, between 150 and 200 feet, occupying even ground raised but little above the neighbouring brooks. Angular flints are common in the deposits near the Chalk outcrop in the northern part of this tract. Shallow workings (now mostly overgrown) are seen by the windmill south-east of Barn Green; on the common south-east of Wecock; east of Padnell Brickyard; and in the southern part of the patch north-east of Waterloo (Waterlooville).

Rowland's Hill (180 feet), south of Rowland's Castle Station, is capped by coarse gravel, exposed to a depth of 6 feet in the brick-pits at the northern end. The gravel around Prospect Farm (150 feet ?) seems thin and loamy.

A clear section in the deposit covering the wooded plateau of Emsworth Common (142 feet) is shown in a big pit by the cross-roads north-east of East Leigh House. The excavation is about 12 feet deep in ochreous, loamy to clayey gravel, indistinctly bedded, and in places much disturbed, as if by lateral compression. Well-rolled pebbles from the Tertiary beds are common, but the bulk of the flints are subangular to angular.

The adjacent deposit, at about the same height, on Westbourne Common is of a different type. Here a large proportion of the flints in the coarse, reddish, sandy gravel dug on the northern edge of the Common are roughly rounded and battered-looking, and form a marked contrast both to the subangular flints and to the smoothly-worn Tertiary pebbles associated with them. Except in its colour, this gravel closely resembles the coarser parts of the modern shingle on the coast to the south; and there seems no reason to doubt that Prestwich was right in regarding it as a remnant of raised beach.[1]

Passing now to the south-western part of the district:—Plateau Gravel is seen to be well developed above the right bank of the River Meon near Titchfield. It there occupies a dissected plateau which slopes southward, from about 150 feet O.D. at the edge of the London Clay escarpment near Little Park, to about 45 feet at the southern boundary of the district, three miles distant. The inclination, though not uniform, is generally low; but in the vicinity of Great Posbrook there is a rather quick descent between the 100 and 50 feet levels, dividing the plateau into two steps (Fig. 13), as Mr. T. Codrington[2] has pointed out. It may be mentioned here that a similar but more marked change of gradient occurs to the east of the Meon Valley, between the Titchfield-Fareham road and the boundary of the Brickearth east of Hollom House (*see* Fig. 14, p. 74).

[1] 'On the Westward Extension of the Old Raised Beach of Brighton, &c.,' *Quart. Journ. Geol. Soc.*, vol. xv, 1859, p. 220.

[2] 'On the Superficial Deposits of the South of Hampshire, &c.,' *Quart. Journ. Geol. Soc.*, vol. xxvi, 1870, p. 583, and Plate xxxvii, fig. 7.

N.B.—Figures 13 and 14 of the present Memoir are based as to section-line and profile on figs. 7 and 8, respectively, of T. Codrington's paper.

Along the line of the Netley Railway near Titchfield Park Farm (*see* fig. 8, p. 48) the gravel attains a thickness of 15 feet. It is described[1] as being sandy, ochreous, and partly stratified; and as containing bands and masses of sand and loam—the latter probably derived from the Bracklesham

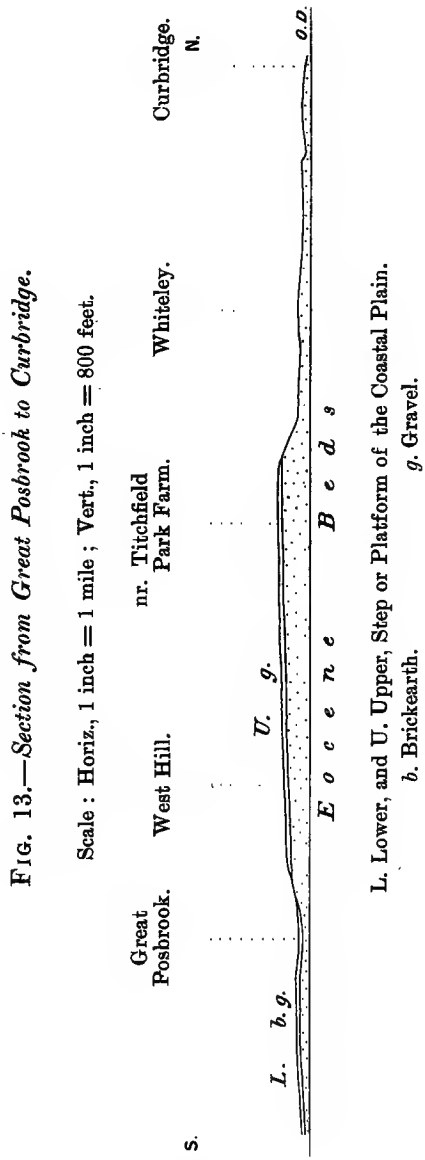


FIG. 13.—*Section from Great Posbrook to Curbridge.*

Scale: Horiz., 1 inch = 1 mile; Vert., 1 inch = 800 feet.

Beds. Flint-pebbles are common in the lower part of the deposit, and in places even exceed in number the subangular flints.

Gravel has been dug to a depth of 8 feet on the eastern side of the Titchfield-Southampton road, two-thirds of a mile west of Segenworth.

[1] J. W. Elwes, *Pap. & Proc. Hamps. Field Club*, No. ii, 1888, p. 35; and MS. notes by W. Whitaker in Geol. Survey Office.

The section is now obscured, but an adjacent working, on the western side of this road, shows a less thickness of fine to coarse, subangular and pebbly gravel, with small rounded blocks or cobbles of sarsen and iron-sandstone, resting unevenly on Bracklesham sand. The sarsens are of two kinds; the commoner sort being of brown sandstone; the other consisting of silicified, fine-grained, loamy sand of dull grey tint. An example of the latter sort seen by the writer exhibited many of the small tubular cavities which are usually ascribed to rootlets, but which in this instance were more suggestive of the borings of some animal.

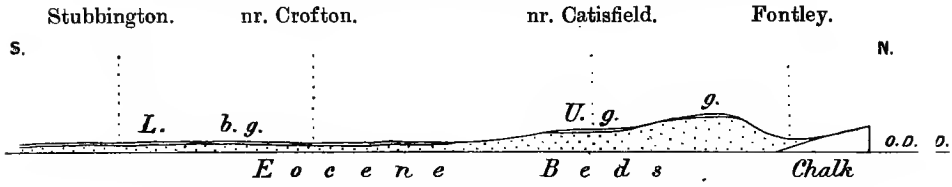
Farther south there are old gravel-pits west of West Hill and of Great Posbrook, but no good sections short of the coast near Titchfield Haven, about half a mile beyond the boundary of the map. There the gravel—of warm red-brown tint and interstratified with sandy loam—forms a low cliff, rising to between 20 and 30 feet above high-water mark. It has yielded Palaeolithic implements of Acheulian types.[1]

Stratified ferruginous gravel, with a high percentage of flint-pebbles, extends along the top of the bluff (about 150 feet) south of Fontley. It contains much interbedded sand and loam, and is partly covered by clayey loam with scattered stones. A pit a quarter of a mile north of the Hospital shows 8 feet of the gravel, mostly of fine texture, resting unevenly on the Bagshot Sands. In a neighbouring section (fig. 10, p. 60), the gravel is cemented in places by iron oxide. Near Uplands House the deposit is thin, much of it occupying shallow indentations in the weathered surface of the London Clay.

The four little patches (about 100–115 feet) north of the high road near Catisfield also seem thin, but the deposit at Hollom Lodge is said to have been dug to a depth of 8 feet on the north side of that house, in a pit which now shows half that thickness of roughly-bedded gravel with lenticles of loam.

FIG. 14.—*Section from Stubbington to Fontley.*

Scale : Horiz., 1 inch = 1 mile ; Vert., 1 inch = 800 feet.



L. Lower, and U. Upper, Step or Platform of the Coastal Plain.
b. Brickearth *g*. Gravel.

South-east of Hollom Lodge the ground falls rather quickly to the wide brickearth-covered flat about Crofton (fig. 14). The gravel on this lower step is of the usual subangular type, but mostly of fine texture, and not clearly demarcated from the Brickearth. The best exposures are in the road cuttings on either side of the brook at Crofton.

Fareham stands on a gravel-covered terrace 40 to 50 feet above Fareham Creek, and a smaller terrace occurs at about the same height at North Fareham. In both places the gravel seems rather loamy, but no satisfactory exposures were observed.

On the hill above Wallington a small unmapped patch of loamy gravel has been worked in a shallow pit midway between the Water Works and the Raised Beach. The deposit is of fine texture, but otherwise of the common, fluvial type.

The gravel which extends from Cams Hall towards Porchester Station occupies ground which slopes gently southward, from about 50 to about 30 feet above sea-level. Pits close to the railway, one mile west of the

[1] J. Evans, 'On some recent Discoveries of Flint Implements . . . in Hants and Wilts,' *Quart. Journ. Geol. Soc.*, vol. xx. 1864, p. 188, and 'Ancient Stone Implements,' 2nd ed., 1897, pp. 622. 626.

station, show 8 to 10 feet of it; fine and well current-bedded in the upper part; rather coarse and more evenly stratified below; and ochreous and sandy throughout. Though mainly subangular, the flints have a smoother and more worn appearance than usual, and a comparison with the subangular flint-shingle of the modern beach at Southsea strengthens the impression that this gravel is, at least in part, marine. It is covered unevenly by brown loam, which thickens southward (from a few inches to a few feet) with the slope of the ground.

Valley Gravel.

The superficial deposits mapped as River and Valley Gravel occur on the sides and bottoms of the valleys in various parts of the district, and also in wide sheets on the coastal plain east of Portsdown.

There is little or nothing to distinguish the higher members of this group from the Plateau deposits: the composition and structure are the same; the mode of occurrence not clearly differentiated; and the overlap in altitude in places is considerable. The lower Valley Gravels, however, are frequently characterised by the presence of chalk, in the form of angular and subangular blocks, pebbles, and granular paste resembling decayed mortar. The chalky gravel—known as Combe (or Coombe) Rock—probably occurs in all the larger valleys that drain, or are capable of draining, the Chalk country; but it is more often to be seen on the lower slopes of the coastal plain, where it merges into the overlying Brickearth formation. Weathering converts it into loamy gravel or stony loam, according to the proportion of chalky matter originally present. It is not unlikely that some of the unstratified loamy gravels of higher antiquity (whether of the 'Valley' or 'Plateau' group) once were of the combe-rock type, and owe their present lack of structure to the irregular shrinkage and settlement incidental to the removal of their calcareous constituents in solution.

Allied to combe rock are certain accumulations of chalk rubble and of angular flints, which do not appear on the map. They are of some economic importance, and examples of them will be mentioned in the sequel.

In noticing the principal deposits of Valley Gravel it will be convenient to deal firstly with those in the main river-valleys and their branches, and secondly with those on the coastal plain.

Humble Valley.—The gravels herein rarely rise more than a few feet above the floor of the valley. In the dry bottom east of Franklin Farm on Corhampton Down, a loose gravel of bleached angular flints is dug for road-metal in shallow pits beyond the northern limit assigned to the Valley Gravel on the map, and in other workings near the London-Southampton road.

Narrow gravel-capped terraces or ledges occur on both sides of the main valley near Durley Mill, south-west of Bishop's Waltham.

Meon Valley.—Above Soberton the gravel is confined to the bottom of the valley. Farther down there are small terraces, 20 to 40 feet above the stream, at Mislingford, Wickham, Fareham Park, and Titchfield. The patch of loamy gravel on the Reading Beds at Fareham Park has been dug to a depth of about 6 feet.

Wallington Valley.—Narrow trains of gravel occur in many of the Chalk combes belonging to this valley-system, but good exposures are wanting.

On the Eocene strata at Hipley and at Hart Plain the gravel expands into low-lying flats about a quarter of a mile wide. At World's End, near the former place, there is well-defined terrace about 20 feet above local stream-level. A pit near its northern end shows:—

	Feet.
2. Coarse gravel of angular, subangular, and pebbly flints in brown sandy loam, with some inclusions of sand ...	6 to 12
Thin seam of clay marking uneven base.	
1. Reading Beds: Grey and brown current-bedded sand ...	seen, 5

The gravel has a roughly bedded structure, and in places appears to have been pushed into the underlying sand.

Loose sandy gravel is dug in the low-level flats at Hipley and near East Hoe Mill; also in the bottom south-west of Hart Plain House.

The gravel-covered slope between the two main branches of Wallington River at Southwick looks like a degraded terrace.

Small exposures of low-level deposits can be seen in the river-banks at Wallington and by the Upper Quay at Fareham.

Valley of the Havant Brook.—At Rowland's Castle a good section of the combe rock on the floor of the valley is displayed in a pit by the road to Westbourne, 350 yards south-south-east of the railway station (fig. 15). The succession is:—

	Feet.
Soil; stony loam	0½
2. Brown loamy flint-gravel, unstratified; piped into ...	2–3½
1. Combe Rock: White to pale buff-coloured gravel composed of little-worn flints and lumps of chalk in a groundmass of fine chalk rubble, flint and quartz sand, and mud	seen, 10

FIG. 15.—*Section in the Combe Rock, Rowland's Castle.*

Scale: 1 inch = 16 feet.

Though the junction of the two gravels appears to be sharply defined when viewed from a distance, there is actually a quick passage from one to the other, and it is clear on close inspection that the higher is merely a weathered condition of the lower.

South of Rowland's Castle, small terraces, 20 to 30 feet above the stream-channel, appear on either side of the valley east of Durrants; but they die out above the point where the valley opens on the coastal plain, near East Leigh House.

Ems Valley.—There is a good deal of very stony ground, indicating the presence of angular-flint gravel, in the higher branches of this valley. Loose flints in gritty loam have been dug in the Stoughton branch as far up as North Marden Down.

Aldsworth, near Westbourne, stands on an ill-defined terrace about 40 feet above the Ems. Most of the gravel mapped below the contour of 100 feet hereabouts is on a strong slope, and appears to be merely a wash from the higher ground.

Coastal Plain.—The spread of gravel east of the Ems Valley covers a broad terrace, which is almost level (at about 115 feet O.D.) near Racton Park Wood, but which has a gentle eastward to south-eastward inclination

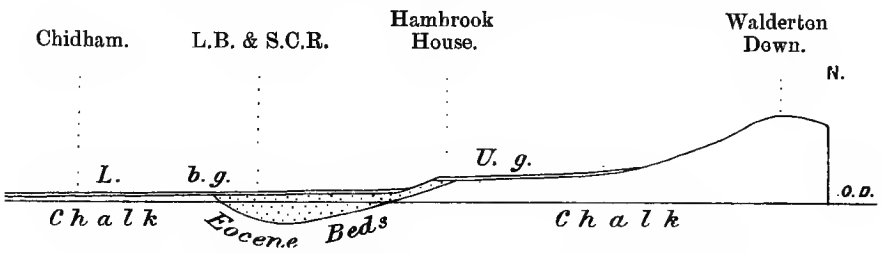
near Funtington. Northward, the gravel thins away to an indefinite boundary on the rising ground which culminates in Walderton Down. To the south it ends, or breaks down into a sort of talus, along the edge of a low bluff, whose upper and lower limits roughly coincide with the contours of 100 and 50 feet respectively (*see* fig. 16). The best exposure of the gravel is afforded by a large, disused excavation, on the 100 feet contour, nearly half a mile east of Woodmancote. It there covers an uneven surface of Chalk to a depth of about 10 feet, and presents the usual mixture of angular and subangular flints, and Tertiary flint-pebbles. The gravel is unstratified.

The bluff is traceable eastward from the River Ems into the area of the Chichester map; also westward, along the southern side of Emsworth Common to the Havant Brook; and there can be but little doubt that the slope which separates the upper and lower deposits of Plateau Gravel near Titchfield (p. 72) is part of the same feature.

In the lower ground that inclines gently southward from the foot of the bluff, much of the gravel underlying the Brickearth is chalky. It has its chief development in the neighbourhood of Havant, and appears to thin away to the east. Wells at Havant indicate a range in thickness of from 8 to 21 feet. Others at New Brighton and Emsworth show from 4 to 8 feet, while in places north of Bosham gravel seems to be wanting.

FIG. 16.—*Section from Chidham to Walderton Down.*

Scale: Horiz., 1 inch = 1 mile; Vert., 1 inch = 800 feet.



L. Lower, and U. Upper, Step or Platform of the Coastal Plain.
b. Brickearth. *g.* Gravel.

Chalky gravel, passing up into stony loam, is exposed, among other places, in small pits by the railway 3 furlongs west of Havant Station; in a deep ditch by the mill west of Langstone; and on the shore of Langstone Harbour, near Warblington Church. The section in the last of these localities is described below (p. 78, and fig. 17).

Erratic boulders, such as occur in or beneath the low-level gravel in the southern parts of Portsea and Hayling Islands, a few miles to the south, are rare or absent here.

At the Waterworks by the railway south of Bedhampton the gravel has been proved to a depth of 18 feet. West of this village it does not emerge from beneath the newer deposits short of Porchester, where a poor exposure of its loamy facies can be seen in the outer bailey of the Castle.

Before passing to the consideration of the Brickearth, some mention should be made of the sheet of chalk and flint rubble which occurs on the southern slope of Portsdown, and of which several exposures are presented in the hollow roads north of Farlington, Cosham, and Porchester. The upper edge of this accumulation follows the foot of the higher and steeper part of the Down, and its base, falling southward at gradients exceeding those of the roads, passes out of sight to unknown depths beneath the surface of the ground.

The clearest section is seen at the northern end of Cosham, in a pit on the eastern side of the Portsmouth-Guildford road, which there runs through a cutting at least 15 feet deep in the rubble. The roughly-bedded structure usually possessed by deposits of this kind, and the grouping of the flints in bands, are well displayed in the pit. To judge from the thickness of the zone of weathering, which ranges up to 3 feet here and rather more in some other places, the rubble is of about the same age as the chalky bottom-gravel or combe rock in the river valleys, and on the lower slopes of the coastal plain east of Portsdown.

It is noteworthy in this connection that 29 feet of a deposit described as "chalk marl and stones," and as "reconstructed material," was found between low-level gravel and the Chalk in a boring south of Bedhampton [1]

Brickearth.

The brown loam which thinly cloaks the bevelled edges of the Chalk and the Eocene Beds on the lower step of the coastal plain, is mainly a mixture of quartz and flint sand and ferruginous clay, though finely-divided chalk is an important constituent in some places east of Fareham. Scattered flints are common; fine gravelly seams also; and these inclusions of coarser material, increasing in frequency downwards, serve to connect the Brickearth with the gravel on which it often rests. Near the surface of the ground the Brickearth has a vesicular structure, and seldom shows any sign of bedding, but the more compact unweathered portions farther down frequently exhibit some lamination which is more clearly seen in dried hand-specimens.

About Great Posbrook and Crofton, near Titchfield, the Brickearth is mostly thin (1 to 3 feet) and sandy. Towards the coast it becomes thicker and still more arenaceous; and in the low cliffs at Hill Head (Sheet 331), two miles south of Titchfield, it consists largely of pale greenish-yellow loamy sand, which would be hardly distinguishable from the underlying sand of the Bracklesham Beds were it not for the included seams of small, bleached, subangular flints. These last are associated with incompletely rounded pebbles, and have a smoother and more wave-worn appearance than the flints of the Brickearth in the area of the Fareham map.

A rather coarse brown loam rises on the sides of the Wallington Valley, to a height of 20 feet or more above the level of the Alluvium, near North Fareham, and is exposed in road-banks east of that place.

Farther east, other road-side exposures of more or less stony and ferruginous loams were observed at Porchester, to the east of the Barracks at Hilsea south of Cosham, and in the western part of Havant.

Near Warblington Church the banks of Langstone Harbour give the following section (fig. 17):—

	Feet.
3. Soil: grey to brown and loamy, with scattered flints and Recent land-shells	to 2
2. Brickearth: warm brown and yellow laminated marly loam, with seams of fine flint and chalk gravel in the lower part	to 3
passing into and filling pipes in—	
1. Gravel (combe rock) composed of chalk and flints in a firm ground-mass of brown loamy marl	seen, 2

The gravel (1) also underlies the modern beach-shingle (*b*), and passes southward beneath the muddy alluvium (*a*) on the bottom of the harbour.

The Brickearth is dug in shallow pits at the brickyards north of New Brighton, and south of Newells. In the latter locality the lower part of the deposit is strongly calcareous, and can be seen passing, at a depth of about 3 feet, into fine gravel of white angular flints and bits of chalk.

[1] W. Whitaker, 'Water Supply of Hampshire' (*Mem. Geol. Surv.*), 1910, p. 39.

In a well at Bosham,[1] 18 feet of "Brickearth, &c.," was found above the Chalk. In this part of the district the upper layers of the Chalk are in a rotten and dirty condition, and have been worked as 'marl' for agricultural purposes at Chidham.

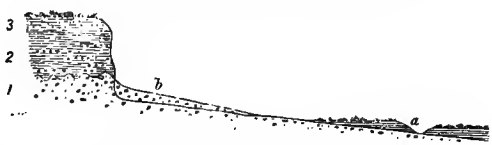
Sequence of Deposits.

The oldest of the superficial deposits described in the foregoing pages of the present chapter almost certainly is the gravel on the summit of the ridge above Rooksbury, east of Wickham. This seems once to have formed part of the bed of a stream running from the Chalk country on the north—perhaps the River Meon. It is the only local gravel of fluvial aspect that as yet can be referred with much probability to the Newer Pliocene.

The next set of deposits belongs to a much later stage in the development of the existing physiography, and the identity of the responsible streams is, in many cases, less open to question. It includes the gravels north-east of Curdridge; about Bere Farm south-west of Soberton Heath; on the Park Place ridge west of Wickham; at and north of Titchfield Park Farm; west of

Fig. 17.—*Section at Langstone Harbour, near Warblington.*

Vertical scale: 1 inch = 16 feet.



1. Gravel. 2. Brickearth. 3. Soil. *a*. Alluvium. *b*. Beach.

Uplands House near Fareham; on Rowland's Hill south of Rowland's Castle; and at Emsworth Common. There seems little to choose between these in point of age. They mark a general pause in the valley-deepening process, and a concomitant aggradation of the stream-channels, which appear to have coincided with the invasion of the southern part of the district by the sea.

How far this marine incursion was due to subsidence, how far to coast-erosion, cannot be determined; nor is it possible exactly to define its northern limit in this district. To judge from the character of the drainage on the landward side of Portsdown, however, the sea did not advance much to the north of the highest known deposits of marine shingle, at Westbourne Common and Downend (Portsdown). These differ in altitude by about 40 feet, and may not be strictly contemporaneous, but, having regard to their position, and to the configuration of the ground along the northern boundary of the coastal plain, it seems probable that the highest and northernmost of the Pleistocene strand-lines, entering this area from the east on the Chalk near Funtington, passed a little north of that village to the neighbourhood of Racton Church; proceeded thence, on Eocene strata, along a curving course by Westbourne Common and Havant, to the vicinity of Farlington; thence westward, on the Chalk again,

[1] W. Whitaker and C. Reid, 'Water Supply of Sussex' (*Mem. Geol. Survey*), 1899, p. 15

across the southern slope of Portsdown and rather north of the Downend raised beach; and continued, on Eocene terrane, near the line of the Netley Railway, to the western boundary of the district.

No sign of the cliffs that once, presumably, existed along this line, or near it, has been observed. Some remnants of them may survive beneath the talus on the slopes of the Chalk, but this seems unlikely, considering the high stand of the old beach on Portsdown, and of the great amount of erosion that has taken place in the southern part of the district since that beach was formed.[1]

But although the cliffs have disappeared, gently-inclined platforms worn by the sea during its advance and retreat are still recognisable, at two distinct levels or stages. Remnants of the higher platform are seen in the gravel-capped plateaux and terraces, east and west of Titchfield and about Funtington, which jointly form the 'upper step' of the coastal plain (Figs. 13, 14, and 16). The gravels themselves, while most probably embodying the débris of marine sediments, are on the whole of fluvial character, and doubtless were spread out by the Meon, Ems, and minor streams as they extended their courses southward *pari passu* with the retreat of the sea. The Plateau Gravels in the Forest of Bere may be of about the same age as these deposits.

Whether the sea temporarily withdrew or not from the area under consideration in the interval between the cutting of the two platforms, there is nothing to show. The lower platform, of which a good deal remains, apparently in a little-altered condition, was developed, to some extent, at the expense of the upper one; the bluff above the 50 feet level on the coastal plain east and west of Portsdown marking the position of the low cliff that formed their common limit at a critical moment in the later history of the marine invasion. The bluff is not clearly discernible on the southern slope of Portsdown, and may never have been so pronounced there as in the country to east and west: it is possible, too, that much of it is hidden by the thick scree of rubble, to which attention has been drawn.

From the foot of the bluff the lower platform falls away at a decreasing gradient, and is continued southward in the Islands of Portsea, Hayling, and Thorney. The deposits which cover it in the area of Sheet 316 are mainly of non-marine types,[2] and

[1] The base of the well-known buried cliff at Kemptown, Brighton, is within 15 feet of present high-water mark, and the shore-line which it indicates may be much more recent than that under consideration.

[2] Eastward of this district, marine deposits (overlapped by subaërial) occur on both platforms, which, however, become less distinct in that direction. See, especially, C. Reid, 'Country around Chichester' (*Mem. Geol. Surv.*), 1903, pp. 39–41; J. Prestwich, 'The Raised Beaches and Head or Rubble-drift, &c,' *Quart. Journ. Geol. Soc.*, vol. xlviii, 1892, pp. 269–272; R. Godwin-Austen, 'On the Newer Tertiary Deposits of the Sussex Coast,' *ibid.*, vol. xiii, 1857, pp. 47, 48.

The raised beach of Kemptown, though usually regarded as the equivalent of that at Portsdown, is more likely to belong to the lower platform than to the upper.

The writer thinks it inadvisable here to attempt any correlation of the superficial deposits in the area of the Fareham map with the Pleistocene sediments of the Selsey promontory.

must have been laid down after the emergence of this part of the Pleistocene sea floor. The only beach-like material that the writer observed is the shingly gravel west of Porchester station. This is at the higher margin of the platform, and may be roughly correlated with the fluvial terrace-gravel at Fareham, North Fareham, Southwick, and World's End, in the basin of the Wallington River; and with that south of Great Posbrook, near Titchfield—all of which are older than the combe rock and other gravels in the bottom of the valleys, and on the levels near Havant.

Mr. Clement Reid's explanation of the combe rock,[1] *i.e.*, that it resulted from the fall of summer rains on a shattered surface of Chalk and other strata, rendered impervious by freezing during winters of Arctic severity, is so well known, and so widely accepted, that there is no need to enlarge upon it in this place. The Brickearth into which this gravel passes, and by which it is overlapped, is mainly a flood deposit, formed under similar conditions; partly at the same time, partly at a rather later date, when, owing probably to amelioration of the climate, the discharges of surface-water upon the coastal plain from the high ground to the north had become less violent.

[1] 'On the Origin of Dry Chalk Valleys and of Coombe Rock,' *Quart. Journ. Geol. Soc.*, vol. xliii, 1887, pp. 364–371; and 'The Pleistocene Deposits of the Sussex Coast, &c.,' *ibid.*, vol. xlviii, 1892, p. 347.

Postscript.—A description of an exhibit of flint-implements, obtained from several localities in this district by Colonel A. W. Jamieson, is given in *Proc. Geol. Soc.*, No. 947, 1913, which was published while the present memoir was in the press.

CHAPTER XV.

ALLUVIUM.

By the close of the Pleistocene period, the larger streams had entrenched themselves in the lower platform of the coastal plain, and were running in channels which, where they crossed the southern boundary of this district, were perhaps 20 to 30 feet below the level reached by ordinary high tides at the present day. At that time the coast-line lay farther south than now, and it is to be inferred that the streams in question flowed down to it in shallow valleys cut in the gravel and brickearth-covered flats of which Portsea and Hayling Islands are not inconsiderable remnants.

Since then, however, subsidence has brought the sea once more into the area of the Fareham map, drowning the lower reaches of the river-valleys, or converting them into tidal creeks, from which the existing Harbours of Portsmouth, Langstone, and Chichester have been developed by a process of lateral erosion still going on. The same movement, aided by changing climatic conditions, has brought about a partial aggradation of the valleys, mainly by sediments of fine texture, not only near the coast but also for distances of many miles inland.

These Recent sediments, constituting the Alluvium of the geological map, are broadly divisible into two classes, namely, (1) the purely freshwater deposits, mostly of loamy character which, though represented in the harbours, occur chiefly along the stream-courses above the head of the tide; and (2) the estuarine muds and silts, which seem to be confined to the harbours and creeks. Layers of gravel and sand are intercalated in the fine-grained deposits of both classes, and peat is associated with the freshwater loams.

The inland alluvium which forms the strips of flood-plain bordering the streams is seldom to be seen in section save in the banks of the rivers and meadow-drains, which reveal two or three feet, at most, of the upper layers. These are usually friable, earthy, and of brown tint above water-level; greyish, compact, and clayey-looking below. Calcareous matter is commonly present, mostly in the form of finely-divided chalk. Shells of freshwater and land molluscs occur, but apparently nowhere in numbers sufficient to form true shell-marl.

Exposures of the kind mentioned above recur at short intervals all along the Meon Valley; others are to be seen at Bishop's Waltham, Wallington, Westbourne, and, in short, in most of the inland localities where Alluvium is indicated on the map; but very few of them call for particular notice.

In a sample of peaty loam from the Meon Valley, taken from a ditch west of the road-bridge near Great Fontley Mill, Mr. A. S. Kennard recognised the following common species of mollusca:—*Arion sp.*, *Hygromia hispida* (Linn.), *H. rufescens*

(Penn.), *Limnaea palustris* (Müll.), *Planorbis umbilicatus* (Müll.), *P. leucostoma* (Mill.), *Physa hypnorum* (Linn.), *Bithynia tentaculata* (Linn.).

In the same valley, a trial-boring, put down on the right bank of the river at the railway culvert near Segenworth, proved:—

	Feet.
"Soil	1½
Light-coloured sandy clay	2½
Soft dark peaty clay	4
Alluvial deposit, with sand and small shells ...	2
Gravel	4 "[1]

The lowest bed most probably is part of the Valley Gravel, by which a good deal of the Recent alluvium is underlain.

The grey and brown loams bordering the tributary brook at Crofton appear to consist of washings from the non-calcareous Brickearth in that neighbourhood.

In the Hamble Valley near Curbridge an oaken dug-out canoe was found, in 1888, at a depth of about 5 feet in alluvial mud, in an excavation designed for a boat-house on the Fairthorne estate.[2]

There are indications of peat in the Ems Valley above Westbourne.

The alluvium exposed on the foreshores of the creeks and harbours at low tide consists mainly of brownish to bluish-grey mud; more or less calcareous, and possessing an unpleasant, 'fishy' odour. The mud and associated deposits are said to attain a thickness of 35 feet at the Docks in Portsmouth Harbour (south of this district), where old land-surfaces with peat, and with tree-stumps rooted in Eocene clay, have been observed extending to depths of from 2 to about 17 feet below low-water mark, and covered with shingle and mud containing marine and estuarine shells.[3]

The mud accumulates most rapidly on the sides of the deep-water channels, as C. J. A. Meÿer has pointed out. Above mid-tide level, deposition is slow, and alternates with erosion, which is predominant near high-water mark.

Under the combined attack of weather, waves, and tide, the low shores of the harbours in many places are wasting back, so that the harbours themselves, while slowly shallowing, are also altering in shape, and seem to be increasing in area.

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[1] Water Supply of Hampshire (*Mem. Geol. Surv.*), 1910, p. 176.

[2] Anon., *Pap. & Proc. Hamps. Field Club*, No. iii, 1889, p. 90.

[3] *See* H. James, 'On a Section exposed . . . in Portsmouth Dock-yard,' *Quart. Journ. Geol. Soc.*, vol. iii, 1847, pp. 249–251; C. J. A. Meÿer, 'On Lower Tertiary Deposits recently exposed at Portsmouth,' *ibid.*, vol. xxvii, 1871, pp. 83, 84; and C. Evans, 'On the Geology of the neighbourhood of Portsmouth, &c.,' *Proc. Geol. Assoc.*, vol. ii, 1873, pp. 173, 174.

CHAPTER XVI.

ECONOMIC GEOLOGY.

Soils.

The map-sheet explained in the present work forms in itself an index to the general character of the local soils, for these, in their mineral constituents, usually resemble the underlying solid and superficial formations whose boundaries are there defined; and with respect to the areas occupied by the Upper Chalk, where this resemblance is least marked, a good deal of information is conveyed in printed comments. But the nature of the soil does not depend solely upon that of the subsoil: there are the organic components to be taken into account, and other important factors, such as aspect, declivity, and the transporting effects of wind and rain, whereby the products of the weathering of a given rock are supplemented or replaced by materials introduced from other sources. A full discussion of the local soils, however, would be beyond the scope of this memoir, which is not primarily concerned with questions of applied geology. All that can here be offered are a few short notes on the salient regolithic features of the several formations indicated on the map.

The soils of the *Folkestone Beds* are mostly thin, light, and sandy on the hillocks, but contain some workable loam in the lower grounds. They are still largely under heath.

The stiff clays and marls of the lower and middle beds of the *Gault* form heavy land, the low-lying parts of which are occupied by marsh and moist meadows, the higher parts by oak-copses, as on the ridge south-west of Rogate Station. The soils of the pastured slopes on the upper beds of this formation owe their better quality, in a measure, to the presence of material derived from the escarpment of the Upper Greensand malmstone. Good exposures of malmy wash on the Gault are seen in the brick-pits north of West Harting.

Warm, friable, loamy malms, of grey to light-brown tints, and containing in places an appreciable quantity of coarse quartz-sand of uncertain origin, thickly cover the even top of the *Upper Greensand* terrace near Buriton and the Hartings. On the whole of good quality, they seem to be rather deficient in lime near the northern edge of the terrace. The malm-lands are mostly arable. Hops are raised on them at West Harting, and, more extensively, in the tract west of the Portsmouth-Guildford road near Buriton.

The fine grey marls of the *Lower Chalk* also are mainly under the plough, and on the gentler slopes seem not less fertile than the malm, though they are troublesome to work in wet weather, and are apt to be heavy at all times in the watered bottoms.

On the outcrop of the *Middle Chalk* the slopes are generally too steep, and the soil too scanty, to be of much use save for grazing. Where, however, the slopes are more moderate than usual, as about Exton and Meonstoke, there are some tracts of tolerably good arable loam.

The *Upper Chalk* soils are extremely variable, changing in character from field to field, often with little regard to the contour of the ground. On the uplands in the northern part of the district they are mostly light, stony loams, under grass, scrub, and copse, but with some tracts of heavy clay-loam on and around the patches of Clay-with-Flints. In places south of Butser Hill soil is almost wanting, bare chalk showing between the tufts of grass.

The soil improves in staple towards the boundary of the Eocene beds, but there is a good deal of very stony ground in the bottoms, especially about Chalton and south of Up-Marden. The lands of moderate slope are mostly under the plough. Good examples of ancient cultivation-terraces are to be seen at Catherington and south-west of Clanfield. The weathered rubble on the southern slopes of Portsdown forms pretty good arable soil, despite its stony character; the warm aspect and shelter from the north going far to compensate for any drawbacks.

Pastures and oak-copses alternate on the belts of clay and heavy loam marking the outcrops of the *Reading Beds*. The more tractable loams on the *London Clay* are still largely under timber, though with wide clearings in arable and in permanent or temporary pasture, extending across the tracts of sandy loam on the *Bagshot Beds*, which are partly under heath.

The *Bracklesham* loams also are much wooded. The lighter parts are well adopted for fruit-growing, and are much used for this purpose about Botley and Curdridge. Strawberries are cultivated on a grey, stony loam over the *Plateau Gravel* north-west of Titchfield.

The *Brickearth* flats near the coast afford some of the best agricultural loam in the district, and are cultivated for fruit, flowers, and vegetables, as well as for dairy and other farm produce. Much of the inland *Alluvium* is occupied by water-meadows. Some of the estuarine mud-banks in Chichester Harbour and other places are grown with a tall grass (*Spartina*), known as 'sage,' and occasionally used for thatching.[1]

Land-dressing.—Chalk is still used as dressing, but much less than in former times. The custom of marling is dying out; the farmers themselves seem not to know why. There are doubtful indications of old 'wells,' in which the chalk was mined under the Reading Beds or the Clay-with-Flints, south-east of Horndean, east of Anmore, and at Hoe Cross. At Chidham and elsewhere in the south-eastern part of the district the decayed chalk beneath the superficial deposits was formerly employed for marling the soils on the Brickearth. The pond called Chidmere, south of Chidham church, occupies an old pit dug for this purpose

Building Materials.

Stone.—The hard calcareous rag-beds of the Selbornian Malmstone have been much used for building at South Harting, Buriton, and the neighbouring hamlets. It is the custom here,

[1] F. Townsend, in 'Victoria History of Hampshire,' vol. i, 1900, pp. 52, 54.

as in the Malmstone country near Selbourne, to ornament the mortared joints of masonry with small pieces of carstone from the Lower Greensand—a practice known as "galletting." In the Chalk country to the south, where buildings of roughly dressed or undressed flint are almost as common as those of brick, the same kind of decoration is frequently to be seen, chips of flint replacing the ironstone. Occasionally the flint galleting takes the form of skilfully struck flakes, set on end, as close together as possible, with their sharp edges outward. There is a good example of this work at the inn called Hog's Lodge, a mile north-east of Clanfield. Walls constructed of beach-pebbles are common in the towns and villages near the coast.

Chalk has been but little used for building in this part of the country. A few old cottages partly constructed of blocks of soft Upper Chalk were noted at Bedhampton and Chalton.

Bricks, &c.—The lower beds of the Gault are worked for bricks, tiles, chimney-pots, &c., in a yard south-west of Rogate station, and at the Causeway on the Portsmouth road south of Petersfield; while the upper beds are dug, mostly for field-drains and tiles, near the stream north of West Harting.

The clays and loams most extensively used in the manufacture of bricks and tiles are those of the Reading Beds, which are worked at Bishop's Waltham, Swanmore, and Rowland's Castle on the northern outcrop, and at Fontley, Fareham, and Emsworth on the southern. Disused yards, or traces of such, are seen at Wallington, Padnell, Red Hill, and other places.

Pottery is made from the Reading Beds at Fareham and Bishop's Waltham.

The lower beds of the London Clay are worked, either alone or in conjunction with the Reading Beds, at Bishop's Waltham and Fareham; the upper beds, with the Bagshot Sands, on the high ground south of Fontley.

Though they contain plenty of material suitable for brick-making, the Bracklesham Beds are but little used within the limits of the district under notice. The only yard known to the writer is that near the Hospital north-west of Fareham (*see* p. 60).

The Brickearth formation near the coast is dug for bricks at New Brighton, and near Newells south of Funtington: it formerly supplied yards south of Emsworth and west of Havant station.

The bricks from all these sources are of various shades of red. Their quality depends largely on the process of manufacture employed. "Fareham Reds" have long enjoyed a high reputation, and have been used in some public buildings in London (*e.g.*, St. Thomas's Hospital).[1] On the other hand, a large proportion of the 'clamp' bricks produced locally, and used for the poorer sort of dwellings, do little credit to the brickmaker's art.

The tenacious mottled clay of the Reading Beds, known in the southern parts of Hampshire as "Stamshaw Clay" (after

[1] T. W. Shore, 'The Clays of Hampshire and their Economic Uses,' *Pap. & Proc. Hamps. Field. Club*, No. iv, 1890, p. 43.

a suburb of Portsmouth), is utilised for puddling dams and ponds, and for enclosing the basins and conduits of springs.

Lime and Whiting.—The greyish chalk of the *Holaster subglobosus* Zone is burned for 'stone-lime,' and the whiter beds of the *Rhynchonella cuvieri* Zone for 'white-lime,' at and north-west of Buriton. White-lime, suitable for plastering, is made from the *Actinocamax quadratus* Zone at Bedhampton, and there are evidences of these and other beds of the Upper Chalk having been burned (probably in part for agricultural purposes) at Downend, near Fareham; Wymering; Haslett Copse, north-west of Stoughton; north-east of Ladyholt Park, and elsewhere. Chalk is shipped from Paul's Grove Quay to the Isle of Wight, for use in the manufacture of hydraulic cement.

Whiting, which consists of the fine ground-mass of the purer and softer sorts of chalk, separated by grinding and washing, is made from the *Actinocamax quadratus* and *Belemnitella mucronata* Zones at Downend, east of Fareham.

Road Metal.

The harder beds of the Selbornian Malmstone are used for road-mending about Buriton and the Hartings, and are also hewn into flags and setts for paving.

Flints from the soil over the Chalk, and the flint gravels, are the metalling most commonly employed throughout the district. Flint-pebbles from the Bagshot Sands have been used, to a small extent, in the neighbourhood of North Boarhunt, where the pebble-beds of that formation have their chief development. They serve well enough for minor by-roads, but in places where the traffic is at all heavy their presence in the metalling hastens the disintegration of the surface.

Chalk, whether hard or soft, is commonly put down in farmyards and on cart-tracks—such, indeed, are its chief uses on the farm nowadays. The same material is employed in making-up the causeways on the tidal flats, and for protecting the banks of the harbours.

Water.

The data which serve as the basis of the following notes are drawn partly from Water-supply Memoirs of the Geological Survey,[1] partly from unpublished information collected for that Department by Messrs. W. Whitaker, Clement Reid, and C. E. Hawkins[2] prior to 1900, and by the writer in more recent years.

The rain-fall averages for different parts of the district show a rather wide range; from a maximum of a little more than 37·5 inches per annum along the crest of the South Downs east of Buriton, to a minimum of less than 25 inches on the costal plain south of Fareham and Havant.

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[1] 'Water Supply of Hampshire' (1910), by W. Whitaker; 'Water Supply of Sussex' (1899), by W. Whitaker and C. Reid; and Supplement to the latter (1911), by W. Whitaker.

[2] MS. notes inscribed on the slips of the 6-inch field-maps.

The absorbed rain, probably less than one-third of the total fall, flows away from beneath the high ground in all directions, but mainly southward with the dip of the strata and the inclination of the surface; and part of it reappears in the springs with which many of the low-lying tracts in this district are well provided.

Water for general purposes is obtained from each of the geological formations represented, but the supply from the clays is greatly inferior, both in quality and quantity, to that from the more permeable rocks, such as chalk, sand, and malmstone.

The *Folkestone Beds*, though eminently water-bearing, seem to emit no important springs at their outcrop within the area of the Fareham map. As they consist of readily permeable sands, with a few clay-seams too impersistent to control the underground circulation, much of the water which they absorb may escape by a number of small and obscure outlets in the channels of the brooks that run northward to the River Rother, but it is also likely that a good deal of it flows slowly away southward, beneath the Upper Cretaceous rocks.

It is of interest to note that water from the Folkestone Beds, tapped in a well-boring through the Gault at the Causeway on the Portsmouth road south of Petersfield, overflowed at the surface, until the bore-hole became choked by sand. The existence of artesian conditions at this spot is not easy to explain, for the site (on a ridge, between 240 and 250 feet O.D.) is 20 feet or more higher than the outcrop of the Folkestone Beds a few hundred yards distant to the north, while the low-level of the country on the same and older beds around Petersfield seems to preclude the possibility of the head of water observed being due to pressure in higher gathering-grounds farther north.

From the *Gault*, small supplies of slightly chalybeate water are obtained in wells of little or moderate depth at the Causeway, and about Nyewoods near Rogate railway-station. Before it was deepened by boring, the well at the Causeway, noticed above, drew its water from the Gault, in which it ended at a depth of 58½ feet. In the weathered superficial parts of the Gault on the low ridge at Nyewoods small 'land-springs' occur, which are said to give trouble in the cellars of houses there. Some of the wells on this ridge are shallow—10 to 12 feet.

The *Upper Greensand* (*Malmstone*) contains plenty of water; harder than that of the Folkestone Beds, but of excellent quality. Numerous springs (a few of them indicated on the map) are thrown out along the outcrop of the Gault, and in the ravines which intersect the Malmstone terrace. A well in the southern part of East Harting (Marden House) is 66 feet deep, and another, in the main street at Buriton, north-west of the church, is said to be 90 feet. On the higher grounds near he edge of the Malmstone escarpment, wells probably have to be sunk rather deeper to ensure a constant supply, to judge from the levels of the springs in the neighbouring ravines.

The *Lower Chalk*, whose inferior, marly beds vary much in their permeability, is apt to throw out water at divers levels within a restricted area of sloping ground. This trait is well exhibited in the neighbourhood of East Meon. Besides the principal sources

which are marked on the map, there are several small intermittent springs, examples of which can be seen at times by the roadside between Upper and Lower House Farms, and near Lythe House, south-east of the village.

Perennial springs flow from the lower beds of this division of the Chalk at South Harting and Buriton.

The *Middle Chalk* gives freer passage to percolating waters than the Lower Chalk, and as the greater part of its outcrop here happens to be in high ground it yields few springs at the surface. For the rest, its hydrological character differs little, if at all, from that of the division next to be noticed.

The *Upper Chalk*, in virtue of its permeability, thickness, and extent of outcrop-surface, is by far the most important of the local water-bearing strata. Of the many perennial springs which it affords, the most copious occur in the southern part of the district—notably in the neighbourhood of Bedhampton, whence the water-supply of Portsmouth is largely obtained. Others break out at short intervals along the coast east of Havant; also at Offwell Farm near Southwick, and in Meon Valley near Great Fontley Farm.

On the northern line of outcrop there are constant springs at and east of Bishop's Waltham; near St. Clair's Farm, south of Soberton; at East Hoe Mill; in the Ems Valley east of Aldsworth; and at Northbrook, south-east of Funtington.

Bournes or intermittent springs occur in all the larger valleys of the Chalk country, *e.g.*, at Waterlane Farm (east of Vernon Hill) near Bishop's Waltham, in the Hamble Valley; at Hambledon and Lovedean in the basin of the Wallington River; between Rowland's Castle and Idsworth; and near Watergate House, and at Stoughton, in the Ems Valley.

Swallow-holes, which ingulf part of the water draining from the tracts of Eocene strata to the Chalk, are of common occurrence at or near the northern boundary of the Reading Beds. Good examples can be seen in Hazleton Wood south of Horndean, and between that village and Rowland's Castle. Along the boundary of the Tertiary Beds east of Westbourne, Mr. W. Whitaker[1] notes the existence of a set of depressions, "some of which seem to act alternately as swallow-holes or springs," according as the season is dry or wet. The swallow-hole marked on the map south-west of Prinsted appeared in 1891; a vertical-sided hollow, about 10 feet deep by 30 wide, being formed in the surface of a field, by the settlement of a mass of gravel and loam into a pipe in the Chalk.

In the high grounds on the Upper Chalk, water is got from wells of various depths, down to 350 feet or more from the surface. At Catherington, a well west of the inn is said to be 300 feet deep, and to have been drawn dry in 1887. At Hinton Farm, north-west of this village, the well is stated to be 260 feet deep, and always to have 8 to 9 feet of water in it. As a rule, however, the level of the ground-water in the upland tracts varies considerably with the seasons. At Hambledon the level is reported to vary as much as 60 to 70 feet, and the water in a well "has been

[1] 'Water Supply of Sussex (Supplement),' 1911, p. 146

observed to rise 23 feet in 12 hours."[1] In a well 160 feet deep at a point 100 yards south-west of Woodcroft Farm, east of Chalton, the water is said to come from a 'land-spring' 25 feet down.

Water from the Chalk beneath the Eocene Beds is obtained under artesian or sub-artesian conditions at and south-east of Bishop's Waltham, at Havant, at Mislingford south of Soberton, and probably in other places. From a boring at a brewery in Havant the overflow is stated to be "very strong [rising] to 6 feet above the ground, with force enough to work a turbine," except during a period of two or three months beginning in November.[2] In three borings put down through the Reading Beds at a spot about half a mile south-west of Merchistoun Hall, near Horndean, no water was found.

The *Reading Beds* yield small supplies from their sandy and loamy members. Springs are not uncommon at the northern outcrop, *e.g.*, south-east of Lower Upham; west of Swanmore; east of World's End; at Horndean (by road-side in the village and in Hazleton Wood); at Brickkiln Ponds north of Westbourne Common; and at Newells, south of Funtington.

Concerning the wells in this formation, and in the *London Clay*, little information is available. The wells in the London Clay country are usually shallow, and in many instances probably derive their water from the weathered parts of the Clay and from the superficial deposits. P. J. Martin[3] states that the wells in the northern part of Prinsted, near Emsworth, are sunk 60 or 70 feet in London Clay, "and then water is only procured by percolation from above." Springs are not wanting in the sandy loams which occur at the top of this formation, and which would naturally be grouped with the Bagshot Sands in a map or section designed to show the lie of the water-bearing strata.

The *Bagshot Sands* are fairly well provided with water at and south of Shidfield and at Purbrook Heath, where the width of the outcrop-surface, the underground structure, and other circumstances are favourable for its collection and storage. Small springs are plentiful, from the main-mass of the Sands and from

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[1] H. F. Parsons, quoted in 'Water Supply of Hampshire,' 1910, p. 94.

[2] 'Water Supply of Hampshire,' 1910, pp. 95, 96.

The following new record was received at the Geological Survey Office while the present Memoir was in preparation :—

Well boring at Hermitage (Sussex) near Emsworth, for Mr. C. J. Jones. County, Hampshire. Geol. map, 316. 1-in. map New Series, 316. Made and communicated by Messrs. Duke & Ockenden, Ltd Date, September, 1912. Bored to 306 feet. Rest level of water, 18 feet. Yield, test pumped to 540 gallons per hour.

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
[Superficial]	Ballast	4	—	4	—
[London Clay]	Blue clay	112	—	116	—
	Green sandy clay ...	2	—	118	—
	Rock	—	6	118	6
[Reading Beds]	Mottled clay	111	6	230	—
	Sand, clay and stones...	14	—	244	—
	Chalk and flints ...	62	—	306	—

Used 4½ inch tubes to 253 feet. Water struck at 258 feet and 304 feet.

[3] *Phil. Mag.*, ser. 4, vol. xii, 1856, p. 448.

the larger outliers. Even the little outliers, such as the patch of sand south-east of Durley Street, near Bishop's Waltham, hold some water. Besides the numerous shallow wells sunk in these beds at their outcrops, water is got from them in borings put down through newer strata at Curdridge Common, Wickham, Titchfield, and other places.

The *Bracklesham Beds*, as a source of supply, are little better than the London Clay. The water, which is got from the sandy beds in wells of small or moderate depth, is apt to be chalybeate.

The *Gravels*, where they occur in bulk, and overlie retentive strata, usually contain water, which is soft in the case of the high-level deposits, and generally of good quality in other respects, if care be taken to avoid pollution by sewage (from cesspits) and manure. There are draw-wells or dip-wells in all the larger spreads of gravel, and in many of the smaller, *e.g.*, at Rowland's Hill Farm, south of Rowland's Castle. At Hart Plain House, north-west of Waterloo(ville), the water in a well sunk in low-level gravel is about 3 feet below the surface, and is said never to fail.

The *Brickearth* of the coastal plain is a water-bearing formation of some importance, as many of the smaller dwellings in that part of the district obtain their supplies from it; either directly, in shallow draw- or dip-wells, as about Crofton near Titchfield; or by means of catch-pits sunk in the subjacent Eocene clays, as in the neighbourhood of Emsworth.

Ponds.—The district is well provided with ponds for watering cattle and other purposes, though few are large enough to be shown on the 1-inch map.

Most of the villages that lie in the combes of the Chalk country have their pond at the cross-ways, fed mainly by run-off from the converging roads. On the ridges, too, in localities where the Chalk has a clayey capping, ponds are not infrequent; the largest of them being Rushmere, on the high ground south of Hambledon; and others existing at Blendworth, Catherington, and Upham. Rushmere receives a good deal of its water from an adjacent tract of clayey ground, whence little rills can be seen sometimes flowing across the Hambledon road, even in the summer.

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ONE-INCH MAP, OLD SERIES (1 inch to the mile, or 1 to 63360).

Nos. 1 to 110, which have not yet been replaced by New Series Maps, are issued as whole sheets and quarter-sheets, hand-coloured, in either a "Solid" or a "Drift" edition, or in both. For Memoirs on Old Series Maps, *see* below.

SIX-INCH MAP (6 inches to the mile or 1 to 10560).

Parts of the Six Northern Counties were published on the six-inch scale prior to 1880. Large parts of the Coalfields of South Wales, North Staffordshire Leicestershire, Derbyshire and Nottinghamshire, and the Mining District of Cornwall, have been published on that scale since 1903. Sheets published since 1903 can be procured with the Geological lines, uncoloured 1*s.* 6*d.* each quarter-sheet, or coloured, at the cost of colouring. Some are issued in both a "Drift" and "Solid" edition.

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